Dun Echt Observatory Publications.

VOL. II.

MAURITIUS EXPEDITION, 1874.

DIVISION I.

DETERMINATION OF THE SOLAR PARALLAX BY OBSERVATIONS OF THE MINOR PLANET JUNO (4) AT OPPOSITION;

TOGETHER WITH

A DESCRIPTION OF THE HELIOMETER

USED IN THE OBSERVATIONS.

DUN ECHT, ABERDEEN.

1877.

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ROYAL SOCIETY OF EDINBURGH

DUN ECHT, ABERDEEN.

1877.

EPISTLE DEDICATORY.

I WISH BEFORE ALL to commence by thanking him by whose help and loving assistance I have been enabled to carry to a favourable termination my plans and desires with respect to the observation of the Transit of Venus in 1874.

Had it not been for the interest my Father has always taken in my pursuits, I should not have been able to undertake a work of such magnitude, nor would these pages ever have appeared.

LINDSAY.

PREFACE.

BEFORE SETTING FORTH RESULTS I have considered that it would be desirable to give, in a few words, a short history of my expedition to Mauritius for the observation of the Transit of Venus in 1874.

My preparations were commenced a considerable time before, as I have found that there are always changes necessary in a plan which, though at first sight it appears perfect, still as time goes on is found to be susceptible of modification with advantage to the whole.

In the 'Monthly Notices of the Royal Astronomical Society,' vols. xxxiii. xxxiv., in conjunction with my assistant, Mr. D. Gill, I gave some account of these preparations, which were terminated in the spring of 1874. My arrangements being completed, I sought for a means of transport to Mauritius, but could find none so convenient as that which could be afforded by a yacht of sufficient size to take all my staff and apparatus, &c. &c. I was fortunate enough, with the assistance of my cousin Lord Bury, to find a vessel which suited the purpose admirably—a three-masted schooner of 398 tons, with a crew of twenty-two all told. This vessel I named the 'Venus.'

I had originally intended to go *viâ* the Suez Canal and Aden, and thence by the Seychelles to Mauritius; but I was strongly urged not to attempt the Red Sea in a sailing vessel, owing to uncertainty of the winds, which, if light or contrary, would prove a great source of delay. This caused me some trouble, as I had desired to

determine the longitude between Aden and Mauritius by the transport of fifty-three chronometers.

I therefore determined to send Mr. Gill with the chronometers by Peninsular and Oriental steamship to Aden, and thence by the Messageries Maritimes to Mauritius. I also sent by this route Thomas Kirkwood, a skilled joiner attached to my observatory, with all the wooden houses, domes, &c., so that all should be in readiness on my arrival with the yacht.

I shall give full reports of the chronometric and telegraphic determinations of the longitude of Mauritius in another volume, together with the observations for latitude and time which were made during my stay on the island. I also defer the details of the observations of the transit of Venus proper, comprising those made with the heliometer and the 6-inch equatorial, and the account of the photographic arrangements and discussion of the negative obtained, to the fourth volume.

I left England on July 9, and after a somewhat stormy and wearisome passage arrived at Mauritius, *viâ* the Cape of Good Hope, on November 2, accompanied by Dr. Ralph Copeland, Mr. Henry Davis, and Dr. Blackley, the surgeon of the expedition.

Within eight days I had got all the instruments erected and in position, and work was fairly begun.

I wish now to attempt to express my feelings of gratitude towards those who were so kind to me and mine during my three months' stay on their island. Towards Mons. de Chazal and his family I shall ever bear the warmest feelings of regard and sympathy. He most generously placed at my disposal, during my stay, the house and buildings on his estate of Belmont in the district of Poudre d'Or, in the north-east part of the island, about sixteen miles from Port Louis. When prostrated by fever, had I been his own son I could not have been cared for with more tenderness. Not content with thus ministering to the wants of the present, he executed a deed of gift to the Government of the site upon which my observatory was placed, considering that it would be well, in the interests of science, that the actual spot where the observations were

taken should be preserved, and should not share the fate of the BASE measured in the year 1753–54 by the Abbé La Caille, which unfortunately cannot now be identified. On this ground I claim for Mons. de Chazal the gratitude of future generations of astronomers and geodeticists.

To the Hon. M. Connal, Surveyor-General of the island, I owe my thanks for the great assistance which he rendered me in every way, and also to his assistant-surveyor, Mr. Parsons.

By the kind assistance of Mr. G. M. Watt, the superintendent, my telegraphic determination of differences of longitude between Mr. Meldrum's observatory, the German transit of Venus station (Dr. Löw), and my own station were greatly facilitated.

Mr. Meldrum, the well-known astronomer of Pamplemousse, afforded great and valuable assistance throughout my stay.

Though the preface to a scientific work is not the place for the mention of the amenities of private life, it would ill become me were I not to say a word as to the warm reception I met with on all sides from the inhabitants of the island. It is a common saying that to understand true hospitality one should visit the Colonies, and most truly can I vouch for its accuracy, for had I been able to accept one-tenth part of the kind invitations I daily received I should have had to renounce all hope of preparing for or observing the Transit. Were I to attempt to name those from whom I and my staff received attentions and kindnesses, I should too much prolong my preface. I will therefore content myself with saying that I shall ever bear the liveliest recollections of those gentlemen and ladies whose acquaintance I had the honour of making during my stay on the island.

LINDSAY.

DUN ECHT: *November* 1877.

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INTRODUCTION.

ONE OF THE METHODS employed by us to observe the Transit of Venus at Mauritius in 1874 was measurement, by means of the heliometer, of the distance of centres of the sun and the planet.

In investigating the constants of the instrument previous to the expedition, we had experience of the great accuracy which can be attained in the measurement of the angular distance between two stars by means of the heliometer. This experience led us to propose the method for determining the solar parallax which is described in a paper communicated by us to the Royal Astronomical Society in April 1874, and is published in the 'Monthly Notices' of the Society, vol. xxxiv. p. 279. The method in its simplest form consists in measuring the position angle and distance of a minor planet relative to a star in the evening, and similarly in the morning. The difference of results corrected for motion of the planet gives the data for computing the horizontal parallax. The total parallactic displacement is very considerably less than in the case of an opposition of Mars, or a transit of Venus, but we believed that the great accuracy attainable in the heliometric measurement of the distance of two minute points of light would more than compensate for this defect.

We think these anticipations have been justified by the result, and as the best method for a rigid determination of the solar parallax is one of the most important, as well as one of the most generally interesting, questions which are presented to the astronomer, we have thought it best to submit the following investigation as firstfruits of the expedition.

It is distinctly to be understood that *the result arrived at is not presented as an example of the accuracy of which the method is capable, but is to be regarded merely as a first imperfect experiment, made under somewhat unfavourable and trying circumstances, from which conclusions can be drawn as to the capabilities of the method for the future.*

For this purpose the discussion of the results is given in much greater detail than is otherwise perhaps necessary, but we wish to place every detail and every step with such fulness before the reader that he may be enabled himself to recompute the results, and to deduce for himself such conclusions as we have failed to draw from them.

To this end the instrument and its adjustments will be first described, together with the methods adopted for determining the various instrumental errors and coefficients. These details will pave the way for the reader's better understanding the capabilities of the instrument, and will also be available in the account of the observations of the transit of Venus, to be afterwards published in vol. iv. of the Dun Echt Observatory Publications.

LINDSAY.

DAVID GILL.

THE TRANSIT OF VENUS EXPEDITION.

PART I.

OBSERVATIONS OF THE OPPOSITION OF JUNO. ④

CHAPTER I.

THE HELIOMETER.

AT the end of January 1872 we entered into correspondence with Dr. Auwers, the able and energetic secretary of the German Transit of Venus Commission, regarding the employment of a heliometer in the transit observations; and, on his strong recommendation, Messrs. Repsold, of Hamburg, were employed to construct a heliometer tube and cradle similar to the instruments then being made by them for the Russian Government. In March of the same year Messrs. Repsold contracted to complete the instrument by the end of September 1873: and Messrs. T. Cooke and Sons, of York, undertook to furnish at the same time the equatorial stand and clock-work.

In August 1873 the instrument was completed, and exhibited in the workshops of Messrs. Repsold at the meeting of the Astronomische Gesellschaft held that year in Hamburg.

The design of the instrument had been carefully considered by Drs. Auwers, Winnecke, and Struve, and practically leaves little to be desired to increase either its convenience or accuracy, and the execution throughout has been of the usual excellence for which the workshops of Messrs. Repsold have always been deservedly famous.

The stand by Messrs. Cooke is no less satisfactory—stable, rigid, true, and convenient.

Since every portion of a perfect lens forms a similar image, differing only in brilliancy from the image formed by the whole, if a perfect object-glass is divided by a saw-cut along the line

FIG. 1.

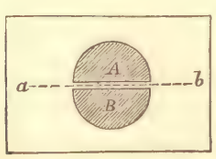


FIG. 2.

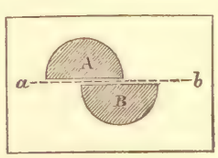
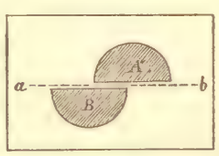


FIG. 3.



a b (fig. 1), but the relative positions of the halves A to B remain the same as before section, the image of a luminous point formed by the two semi-lenses will be the same as that formed by

the whole lens, except that it will be diminished a very small amount in brilliancy, corresponding to the amount which the area of the whole surface is diminished by the saw-cut.

If, however, either segment A or B is moved relatively to the other, during the process of cutting or afterwards, in a plane at right angles to the optical axis, then two images of the luminous point will be formed, separated from each other in direction and distance corresponding with the angular amount and direction through which the segments have been moved—the angular amount being reckoned as tangent of a circle of which the focal length is the radius.

If two distant luminous points are situated nearly in the optical axis of the lens, and in a plane passing through *a b*, a motion of one segment in the direction of *a b* will produce first a double image of each point, and it will be possible, by continuing the motion in the same direction, to cause the image of one luminous point to coincide with the other. The lenses will then have assumed the position of fig. 2. Similarly, of course, a like effect can be produced by displacing the lenses, as in fig. 3. In the one case we should view a point α by segment A, and a point β by segment B; in the other case β would be viewed by A, and α by B.

It is also obvious that between the positions represented in figs. 2 and 3 the relative difference of mutual positions of the lenses is equal to twice that corresponding to the distance between the luminous points.

If, then, we have the means of measuring this relative displacement, and the data for converting into arc, we have a measurement of twice the angular distance between the points.

If, however, the luminous points are not in the plane of *a b*, then, in order to be able to produce a superposition of the images of the luminous points, it will be necessary to rotate the telescope or the object glass round its optical axis, till a plane passing through *a b* coincides with the plane of the luminous points whose distance it is required to measure.

The requirements of a heliometer mounting are therefore the following :—

1. To produce the most perfect means for carrying the halves of a divided object-glass, and separating them exactly and steadily along the line *a b* with the necessary delicacy and ease of movement.

2. To provide the most perfect means of measuring the relative displacement so produced.

3. To provide the means of producing a single image in the direction at right angles to *a b*, so that it may be possible afterwards to form a single image of a single point by moving the lenses in the line *a b* only.

4. To change the direction of the line *a b* by rotation round the optical axis of the telescope, and to provide means for measuring this rotation.

5. To carry the instrument as an equatorial telescope, so that the rotation of the lens round its axis may permit the measurement of angles of position.

In the earlier heliometers, such as the small instruments by Fraunhofer, and the larger instruments made by Merz for Bessel at Königsberg, and Struve at Pulkowa, the segments were mounted on straight slides, and motion was communicated to either semi-objective by means of a screw. Each screw was provided with a micrometer head, the readings of which served to measure the separation of the segments. The screw in such a case was therefore both the means of producing motion as well as of measuring its amount.

The slides carrying the divided object-glass were mounted on a turntable provided with a

toothed edge, and rotation was communicated to the whole by a pinion gearing into the toothed turntable, and worked by a handle coming down to the eye end. Many of these arrangements were attended by serious practical inconvenience.

When the segments move in a plane, and are truly centred when their optical centres are in coincidence, then when the segments are displaced to measure an angle, the rays from a star must fall obliquely on the segment so displaced from the normal point, and the image will be more or less distorted, according to the extent of the angle measured. This fault is also aggravated by the fact that the optical centre of the segment which is moved follows a tangent, to the circle of which the focal length is the radius, and the distance from the ocular is therefore continually increasing, and the star getting farther and farther out of focus, the larger the angle measured.

Both these causes of error are at once got rid of by the contrivance of making the slides, which carry the segments, move in beds whose surfaces are portions of a cylinder, the axis of which passes through the focus at right angles to the optical axis, and in a direction at right angles to the direction of the line *a b*.

The method of measuring an angle by the old arrangement was also objectionable and inconvenient. In practice it soon becomes evident that the highest accuracy can only be arrived at by measuring all distances in reverse positions of the segments, and that the more thoroughly and symmetrically this arrangement is carried out, the more reliable and satisfactory are the results. It is therefore necessary to have the simplest and quickest means to effect this. The usual method was to place one segment near the axis of collimation, and to displace the other segment the necessary amount. Thus the axis of collimation was directed to the star α, and that star viewed through the segment A; the segment B was displaced till the image of star β was brought into coincidence with α; then the telescope was directed to the star β, and that star was now viewed through the segment A, and the segment B was moved back till the image of star α, now viewed through segment B, was brought into coincidence with B, viewed through segment A. Half the difference of the two readings of the screw B converted into arc was the desired measure.

This method was open to two grave objections :—

1. The defect to which allusion was made before—viz. that while one image remained in focus the other was not only displaced from its normal focus, but distorted.

2. Between each reversal much time is lost, because in general distances are measured greater than the field of view, and it is therefore necessary to have recourse to the setting circles when the direction of the collimation axis is changed from star α to star β.

Another method, occasionally, though more seldom, practised with the old form of heliometer, consisted in directing the collimation axis to the middle point between the stars, and displacing the segments symmetrically first, so that α is viewed by A and β by B, and then so that β is viewed by A and α by B.

This method possesses the great advantage that the distortion is very considerably less than half what it is by the former method; both stars are equally and oppositely distorted and equally affected by change of focus; the whole arrangement is more elegant and symmetrical, and there is no necessity to disturb or touch the telescope between the measures. The time lost in making the symmetrical arrangement of the lenses was considered to more than compensate for the advantages gained, combined as it was with the necessity for investigating the errors

and values of two screws instead of one; but it is somewhat surprising that the idea of making the symmetrical adjustment of the lenses in some simple automatic way (as, for example, by the introduction of a common wheel to turn both screws in opposite directions) was not sooner carried out and employed in practice.

In measuring position angles by the old form of heliometer, when the *head* containing the slides is turned, it is obvious that with it must also turn the handles by which motion is communicated to the slides; but the tube being at rest, and the handles necessarily attached in some way to the tube near the eye end, a complete revolution of the *head* becomes impossible without detachment of the handles. The position circle also, being on the turntable which carries the slides, is far removed from the observer's eye, and it becomes necessary to employ a second observer, mounted on some raised platform, or to lower the object end between each observation.

These were both grave practical defects, and the source of much inconvenience and loss of time.

The true remedies for these, as well as most of the other already described defects, were pointed out long ago by the elder Struve, where he says :—

Quelque parfaite que soit la construction actuelle de l'héliomètre, il me paraît que cette construction puisse être encore perfectionnée, surtout sous le rapport de la plus grande facilité des observations. J'ose exprimer ici mes idées, en les soumettant à la décision de juges compétents :—

1. Dans l'héliomètre oculaire, décrit plus haut,[1] M. de Steinheil a donné aux deux moitiés de l'objectif des mouvements simultanés, opposés et correspondants, de sorte que ces moitiés s'éloignent d'une marche égale des deux côtés du zéro, où les centres coincident. Par l'application de ce moyen on éviterait tout changement dans la position de l'oculaire, invariablement fixé alors comme dans toute autre lunette. Je vois bien que cet arrangement ne peut s'exécuter qu'en sacrifiant l'avantage de la mesure par répétition, ou sur différentes portions de l'échelle micrométrique. Mais ce sacrifice ne me paraît d'aucune conséquence, vu qu'il existe des moyens d'examiner l'exactitude des vis avec toute la rigueur désirable.

2. Je préfèrerais un tuyau de laiton à la place du tube en bois en Fraunhofer, et sur lequel le porte-objectif serait fixé sans avoir un mouvement relatif de rotation. Le tuyau entier étant placé d'une manière convenable dans la jatte *k*, le mouvement de rotation pourrait s'effectuer à l'aide d'une verge prolongée depuis le coussinet inférieur *l* de la jatte jusqu'à l'endroit de l'oculaire, verge qui porterait un pignon engrenant dans un cercle denté à fixer sur le corps du tube. Dans cet arrangement l'objectif et l'oculaire auraient toujours un mouvement correspondant de rotation, et l'anneau mobile disparaîtrait. Le même arrangement produirait encore deux avantages précieux. On pourrait faire en premier lieu la lecture de cercle de position tout près de l'oculaire, la division étant tracée sur le corps du tube. Pour ce but les verniers seraient à fixer sur des bras qui portent la jatte *k*. Ayant tracée en second lieu une division rectiligne sur le tuyau intérieur *m* de l'oculaire, avec un index fixé au corps du tube, on aurait directement un thermomètre métallique pour évaluer, à chaque instant, la valeur effective d'une révolution des vis micrométriques du porte-objectif.

Here we have an illustration of the practical talents of that eminent man; he had never used the instrument as he received it, but he said at once, 'Until such and such things are done I will not employ it.' That so many years have been allowed to pass till these suggestions have been appreciated and tried appears to show that we have not yet learned all he taught.

The manner in which these improvements have been carried out will be understood by reference to the plates and the following description.

[1] *Description de l'Observatoire central de Pulkowa*, pp. 195–197.

The *head*, carrying the slides and various arrangements by which motion is communicated to the segments, is represented in Plates I. II. III. IV. V.

Plate I. is a plan of the *head* as seen from the outside, showing the segments A and B and the gun-metal mountings by which they are held and adjusted, and these also form the attachment to the slides by which the segments are moved in the line *a b*.

One of these mountings is screwed down rigidly to its slide by the screws *s s*; the other can be moved in the direction *c d*, by the screws $\sigma\,\sigma$, till perfect coincidence of the optical centres of the segments in the line *c d* is secured, and then is clamped rigidly in position by the screws *s′ s′*. The whole of the *head* is cast in one piece of gun-metal, and its form may be readily understood by reference to the plates. The opening *m m m m m*, which was necessarily left to permit the displacement of the segments, and by which dust would be admitted to the slides and interior of the telescope, is closed by two thin nickel plates attached to the mountings of the segments. These plates fit closely, yet barely touching the surface *m m m m*, and this surface, as well as the thin plates, has a curvature the same as the slides, so that no contact or jamming results from the movement of the segments, and the interior of the telescope is at the same time protected from the entrance of dust. These plates have been omitted in the drawings for sake of distinctness.

Plate II. is a plan of the opposite side of the *head*—that next the eye end—as seen when it is unscrewed from the tube. Plate IV. also represents the same, but in Plate II. the optical centres are in coincidence, whilst in Plate IV. each half of the object glass is displaced fifty divisions of the scale (about 43″ : that is, the instrument is represented as measuring two stars separated 86″).

A careful study of these two drawings, showing the relative changes in the disposition of the various parts, will convey to the reader a clearer understanding of the construction than any written description.

Attached to the bevel wheel at *k* is a handle which, passing down the inside of the tube, terminates in the disc and handle shown at *k* (Plate VI.) A quick motion can be given to the segments in the line *a b* by means of this handle, whilst a delicate motion can be communicated by the thumb and finger applied to the disc. This bevel wheel turns another, on whose steel axis a screw is cut, which in its turn communicates motion to the toothed arc represented in the drawing.

By steel rods provided with ball and socket joints, the construction of which is evident from the drawing, the equal and opposite motions of points equally and oppositely distant from the centre of motion of the arc are conveyed to the slides, whose motion is thus rendered symmetrical with the axis of the telescope.

At *n n n n* are the silver scales by which the amount of separation of the lenses is read off. Approximately the scales and numbers are in coincidence, and read alike, when the optical centres of the lenses are in coincidence; obviously, then, the difference of the readings of the two scales is approximately the distance apart of the optical centres. The necessary accuracy could not, of course, be attained without microscopic aid, and this aid is supplied by the long microscope M (Plate VI.) passing down the inside of the tube, its optical axis directed nearly to the middle point between the scales when the scales are in coincidence. Thus both scales are read by the same micrometer of the same microscope, in a manner easy and convenient to the observer.

The method of reading, and the details of the micrometer, will be more fully detailed afterwards.

The edge of the scale, and the method of fixing it in its place, is well seen in Plate III. The surface of the slide upon which the scale rests is, like the slide itself, a portion of a cylinder of which the focal point is a point in the axis. Each scale is held in position by a brass clip pressed upon it by the screws *t t* (Plates II. III. IV.), the edges of the scales projecting sufficiently to expose the graduation and the figures. By this arrangement the scales are supported freely; the expansion of brass by heat is so nearly that of silver that no sensible strain need result from this cause, nor are the scales so tightly confined that very minute changes cannot take place with sufficient freedom and without distortion.

This method of measurement is undoubtedly very superior to the employment of a screw, where the screw is not only the measuring instrument but also the means of motion.

Apart from the fact that it is an unsound principle to apply force to any delicate standard measure, it is impossible to be sure that the *point d'appui* of the screw is perfectly rigid; and it is with reference to this *point d'appui*—that is, difference of distance from this *point d'appui*—that all measures are made. Also changes in temperature affecting the length of the screw between measures in the two positions of the segments affect the measure not alone by the change in small distance through which the measure is made, but also by the whole change between the *point d'appui* and the point of the screw employed. Added to these sources of error, there are the difficulties and uncertainties which attend the investigation of the errors of a long screw, and the certainty that, however accurately the errors may have been once ascertained, these errors are certainly changing by wear every time the screw is used.

The errors of division of a scale, on the other hand, are not liable to change, and their investigation can be accomplished with the utmost certainty, whilst motion is communicated to the lenses in a manner which is more powerful and convenient, and which is not so liable to the errors caused by change of temperature between two measures.

At *p p p p* (Plate V.) is well shown the circular section of the cylindrical bed in which the slides move, and at *q q q q* the bearing surfaces against which the rollers *r r r r* bear, and by their pressure keep the slides constantly in contact with their cylindrical beds.

The central part of the axis of these rollers is slightly elastic, being an exceedingly strong spring, and by means of the screws shown in Plates II. III. IV. and V. the pressure of these springs, and consequently that of the rollers upon the slides, can be regulated at pleasure.

The screws *k k*, as shown in Plate IV., act against gun-metal bearings, which press sidewards on the slides, and serve to keep the slide rigidly in contact with the central guiding pieces *x x* (Plates II. IV.)

The line *w w w w* shows the strongly ribbed form of the slides, by which their rigidity is secured.

At *τ τ* (Plates I. II. III. IV. V.) is shown the metallic thermometer which has been provided to indicate the temperature of the scale. It consists of a bar of zinc and a bar of steel firmly attached to the head of the screws at *ν ν*, as shown in the drawings. The ends of these bars carry silver plates, as seen in Plate III. Upon the plate attached to the zinc bar is engraved a small scale, and a single line only on the plate attached to the steel bar. The readings of the scale relative to the line as changed by the different coefficients of dilatation of the two metals indicate the temperature.

The prism of total reflection π (Plates II. IV. V.) is mounted on an axis ρ (Plate V.), and this axis is connected by a rod passing inside the tube with the small disc marked π (Plate VI.) The observer by this disc can at pleasure turn the prism on this axis ρ so that it is interposed between the microscope and the scales *n n n n*, and the scales of the metallic thermometer are viewed instead of the scales attached to the slide.

A similar small disc, not visible in Plate VI. because hid by the eye-piece tube E, is connected by a rod with the bevel wheel α. This bevel wheel turns its fellow, which acts on the rod γ (Plates II. and IV.) which turns the pulley β (best seen in Plate III.) This pulley is connected with the pulley β' by an endless chain, and by it the axis δ can be rotated. This axis carries a clip, whose construction is evident from inspection of Plates III. and V. This clip clasps a frame G pivoted on an axis θ. In Plates III. and VI. this frame is shown; in Plates I. and V. it is removed. In the normal state of things this frame occupies the position shown in Plate VI., and does not interfere with rays incident on the object glass in the direction of optical axis, only interrupting those rays which otherwise would fall on the line of section. This frame is filled with wire gauze, such that the area occupied by the wire is nearly equal to the free area, and the whole is exactly counterpoised by the weight *co*. Obviously, then, by acting on the small disc the observer can turn the axis δ so that the wire gauze is laid over either half of the object glass, and thus the brilliancy of the image viewed through that half is diminished one-half. By inclining the frame the amount of light which the wire gauze will allow to pass becomes still more restricted, and nearly total extinction can thus be produced.

Some such provision is of great necessity; indeed, it is impossible otherwise to compare accurately two stars which differ greatly in brilliancy.

Diaphragms of different apertures have in many cases been used. These are objectionable on many grounds, chiefly because it is by no means certain that the focus is rigidly the same for the central and the marginal rays, and experiments with the Oxford heliometer seem to show that very considerable errors are in this way introduced.

Bessel used perforated diaphragms, by which this objectionable feature was in great part overcome, but there is no doubt that wire gauze is still better and more convenient.

Without some arrangement by which the observer can from the eye end moderate the light of either segment, the fatigue and annoyance of constantly climbing up to change the diaphragms at each reversal has a most prejudicial effect on the astronomer's observing powers, and tends to lead him to neglect that constant reversal which is one of the essentials in the highest order of heliometer-observing.

To conclude the description of the arrangements of the *head*, the ends are closed by copper caps, to exclude dust. These are not shown in Plates I. II. III. IV. or V., but one is shown in Plate VI., where, were it not for the cap, the pulley β and the ends of the slides would be visible.

The means of removing the frame G will be readily understood by reference to Plate I., where the piece μ, which keeps the pivot of θ in its notch, is turned to one side; the pivot is then lifted and θ withdrawn from a hole in the end of the axis δ, the frame coming at the same time from between the jaws of the clip ϵ.

When the instrument is not in use the object glass is protected from dust by a circular piece of nickel, curved to lie closely upon the plates which exclude the dust from the aperture

m m m m (Plate I.), already described. This cover is attached to an axis similar to θ, and so held in its place.

The tube is of rolled brass, terminating at the upper end in a strong flange (shown in Plate III.), and the *head* is attached to this flange by strong steel screws.

At the other end of the tube is a strong breech-piece of cast brass, and to this is attached the hollow brass casting E, which carries at its farther end the slide containing the eye end, by which the final adjustment of focus is made.

The strength of the breech-piece and of E are partly necessary as counterpoises of the very considerable weight of the *head*, but the stiffness of E thus attained is also of value in enabling the reading microscope M to be supported by the cross-piece $\zeta\,\zeta\,\zeta$ through which it passes, and its extension also supports the rod connected with the handle *h*, by which motion is communicated to the segments.

The microscope M is not really *supported* by ζ; it is held by an arrangement inside the tube, is adjusted by three screws which press upon a collar in the body of the microscope at η, where one of the screws is shown, and it is only *after* the adjustment has been so effected that the three steadying screws of ζ are brought up to touch.

At λ is shown the reflector, covered with white papier-mâché, by which, through a hole in the breech-piece, light is reflected upon the scale for its illumination. By day the light of the sky is sufficient; by night a lamp held in the observer's hand, supported on a stand, or, better still, held by an assistant, gives an admirable illumination. It is undoubtedly inconvenient for the observer to hold the lamp in one hand and make micrometer readings with the other, and when the object has considerable altitude it is almost impossible. It is generally sufficiently easy to arrange a stand to carry the lamp, by occasionally changing the position of which light can always be thrown upon the reflector; but the constant neighbourhood of a lamp is by no means conducive to the uniformity of temperature so desirable in all parts of the instrument, and on many accounts it is best when this can be done by an assistant.

In the Oxford instrument the scale is illuminated by light emanating from a platinum wire rendered incandescent by the passage of a voltaic current. This method, if not found practically inconvenient, appears to afford an excellent solution of the question, and is probably the best that can be adopted.

Illumination by a lamp attached to a long arm near the object glass may also be successful, but the occasions must frequently occur when the lamp will come under the object glass, and the currents of heated air which must then rise in front of the object glass must be fatal to definition and precise measurement.

Attached to the declination axis is the cast-iron cradle C C C C (Plate VI.), and to the tube are soldered gun-metal rings, turned true, forming pivots, which are ground to fit portions near the extremities of the cradle.

At Q Q is a shoulder, carrying a circle P P.

This shoulder is also ground true, so that when the tube is inserted in the cradle, eye end first, the rings on the tube finally come up to a smooth fit, the shoulder Q comes to its bearing, and the telescope rotates in the cradle like a pivot in its journal.

The damping-ring R R is then slipped on, and fixed by small screws so that the object-glass end can be turned down without fear of the tube slipping out.

Between the two rings or pivots on which the tube rotates is a toothed wheel, which is acted on by a pinion attached to the axis H H. The drawing shows only the cover by which the pinion is enclosed in order to exclude dust. The observer, by acting on this handle, can rotate the tube in its cradle.

In the circle P P is inlaid a ring of silver, and on this divisions have been cut to each 10′. These are read to 30″ by two verniers, of which one is seen at V.

These verniers are read from the eye end by means of telescopes T T, supported on iron arms attached to the cradle, and the readings indicate very nearly true position angles.

The balance of the tube, both about its axis of rotation and about the declination axis, is perfected by the counterpoise χ.

The mounting presents few features not familiar to astronomers generally.

D D is the declination circle, and V its vernier.

Declinations are read off by the telescope Z Z.

By the handle ξ slow motion independent of the clock is given in Æ.

By the handle ψ the instrument is clamped in declination, and behind ψ, concealed in the drawing by ψ, another handle gives slow motion in declination.

Motion is conveyed from the clock by the rod connecting the former with the bevel wheels 1 and 2. These wheels are mounted in a slide, by which either 1 or 2 can be thrown into gear with the central wheel. When 1 is in gear, the instrument is suited for a north latitude; when 2, for a south latitude.

The adjustment for elevation of the polar axis is effected by the screw S.

Three different pieces command all latitudes from 18° to 65°.

Adjustment in the meridian is effected by the flange at F.

When the screws $y\,y\,z$ are loosed, the instrument can be turned to any azimuth, and then when z is clamped slow motion can be communicated by opposing screws ϕ. When all is in adjustment the other screws are clamped.

The drawings are made from the instrument as mounted at Dunecht—latitude 57° 9½′ north.

At its site in Mauritius it was necessary to raise the instrument some height to command the horizon over the photographic houses.

The rock was levelled, and a strong pillar of masonry, with a base of about six feet square, tapering to about three and a half feet square at the top, was built, and had stood for two months before the instrument was placed upon it. This pier was about five feet in height.

Thus mounted the instrument exhibited the greatest stability and permanence of adjustment, but this will be better shown in the discussion of observations.

The drawings and the account of them will probably convey to the reader all necessary information as to the mechanical arrangement of the instrument.

The whole combination was found exceedingly convenient in practice, every motion, adjustment, and reading being possible to the observer without changing his position from the eye end of the telescope, except that for setting to the proper hour angle.

In the observations to be hereafter described this was of no practical consequence, as it was always possible to shift from one star of comparison to another by setting to the proper declination, distance, and position angle, and making a short sweep in Æ in the known direction till the star and planet appeared together in the field of view.

The most serious deficiency was in the slow motion in position angle, but this could generally be overcome by making use of the proper motion of the planet to perfect the final adjustment, and this, when the change of position angle is rapid, is by far the most accurate plan; but when the star of comparison and the planet are very distant, or the star nearly in the path of the planet, then the change of position angle is so slow that too much time would be lost, and the method becomes inapplicable, as of course also in the case of fixed stars; but by careful manipulation and practice errors due to this cause became very small, as will be seen afterwards.

Optically the instrument is no less excellent. The object glass is by Merz, and has an aperture of 4·2 English inches, and a focal length of about 64 inches. Its definition is in the highest degree admirable.

Of course the discs of stars must of necessity appear elongated in the direction which is at right angles to the line of section. This elongation becomes less and less evident the less brilliant are the stars observed, till with stars of the eighth magnitude it is hardly sensible, and it is chiefly with such stars we had to deal.

The elongation of the images is, however, by no means an objectionable feature so far as the measurement of distance is concerned. The elongation is at right angles to the line joining the stars, and therefore, so far as distance is concerned, the separating power of the full aperture is available. In measuring position angles the practical difference is that the size of disc is that due to a two-inch instead of a four-inch aperture.

The instrument is provided with two eye-pieces—powers 80, 170—of which the latter has, with the exception of one occasion, been exclusively used.

All the stars of comparison actually used were brighter than this; the faintest employed was 8·5 magnitude, but the comparisons with this star are, as it happened, the most numerous, and some of the most satisfactory of the whole series. On several occasions the comparisons are continued into very great zenith distances, and far into the morning dawn.

There appears to be no doubt, therefore, that 9th magnitude stars, in favourable atmospheric conditions, might be observed.

Plate VI. shows attached to the tube two mercurial thermometers; on the opposite side of the tube are also two similar thermometers. The use of these will be discussed in connection with the sun diameter and transit of Venus observations.

CHAPTER II.

INVESTIGATION OF THE ERRORS OF DIVISION OF THE HELIOMETER SCALES.

The scales are of silver, attached, as already described, to the two slides which carry the halves of the object glass, and are divided each into 150 divisions, figured at each tenth division from 0 to 15, thus :—

Fig. 4.

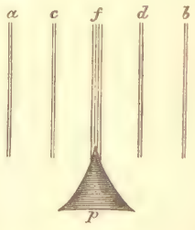
The microscope, already described, thus views both scales at once, and (approximately), when the readings of the scale are identical, the optical centres of the segments are in coincidence. If this condition could always be realised, the difference of the readings of the two scales would give directly the distance measured in terms of the scale.

In practice it is of course necessary to find accurately the difference of the readings when the optical centres are in coincidence. This difference is termed the index error.

The field of view of the microscope as it now stands may be represented thus :—

The webs *a*, *b*, *c*, *d*, and *f* are all attached to the frame which is moved by the micrometer screw.

Fig. 5.



Two turns of the screw correspond very nearly with one division of the scale.

The pointer *p* serves the purpose of the comb in the ordinary microscope, and all the readings of the screw in ordinary observations are made with the two central wires of the group *f*.

The other wires have been introduced for investigation of the errors of division of the scale or screw, and their use will be explained in the following account of these operations.

The Errors of Division.

The first essential in the accurate reduction of observations made with any instrument in which a scale is employed, is an accurate knowledge of the errors of that scale, and it was a matter of considerable thought how best to carry out this investigation.

A very short experience of the instrument showed that, when freed from all systematic error the error of a single complete observation of the distance of two stars was decidedly less

than $\frac{1}{10}$th of a second of arc; and therefore, to do justice to the powers of the instrument, the probable error of the determination of the division errors should not exceed $\pm 0''.02$.

For a radius of 5 feet one second of arc is ·00029 inch, and therefore our desired accuracy corresponds with a probable error of six-millionth parts of an inch.

To attain this it is evident that no ordinary precautions were necessary.

At first we thought of making some temporary arrangement by dismounting the head, and fixing temporary microscopes in such a way that the scale could first be subdivided into two parts; then, changing the distance of the fixed microscopes, subdivide each of these into two parts, and so on, by successive subdivision, until the errors of the scale had been ascertained at such a number of points that the known intervals would come within the field of view, and could be subdivided by the micrometer screw.

Experience of the effect of different illumination in changing the appearance of a division, and its apparent position under the microscope, soon caused the abandonment of this method; and it was determined, if possible, to carry out the whole investigation with the same microscope, and under the same illumination, as that employed in the actual observations.

The primary object was of course to ascertain the errors of division in that portion of the scale employed in observing the transit of Venus, and for this purpose the space comprehended between the divisions 50 and 98 on each scale was selected for the fundamental scale.

It was found that twelve divisions could be seen with sufficient distinctness in the field of view, and accordingly the double wires *a* and *b* were applied to the micrometer frame, at a distance a little less than 24 revolutions of the screw (12 divisions) apart, and at the same time the additional wires *c d* were introduced.

Thus prepared, the microscope head having been set nearly at 0, the slow-motion handle was turned till the image of the division 62 occupied the central, or nearly the central, position between the components of the double web *a*.

The web *a* was now displaced by means of the micrometer screw, and then brought to bisect the division 62 with the greatest possible accuracy, and the reading taken.[1]

The micrometer head is now turned till the division 50 is bisected by *b*, and again read off. The difference of the two readings gives the excess of the interval 50–62 over the space *a b*.[2]

The web *b* is again displaced, and the division 62 again bisected, the head read off; then 50 bisected by *a*, and the head read off.

Thus we have two measures of the space 50–62, and they are so arranged as to eliminate the effect of any progressive change in the microscope with respect to the scale.

The greatest care is requisite in adjusting the focus, to avoid parallax in measuring at so considerable a distance from the centre of the field.

An additional precaution which was found useful was to withdraw the eye far enough to see at the same time the circular aperture of the eye-piece and the image of the web and division. The eye could then be so placed as to see the web apparently exactly in the centre of the aperture of the eye-piece, and thus the effect of any possible parallax is eliminated.

[1] We shall in future, for shortness, use the expression 'bisect a division' to mean that the double web is arranged symmetrically with the division, the division occupying the estimated middle space between the webs.

[2] In all measures the final bisection was made by a screwing-up motion—that is, bearing up against the spring. This is necessary to eliminate 'loss of time.' When the bisection was not judged exact, the motion was reversed about a quarter of a turn and brought up again, always against the spring.

In a similar manner, and with the same precautions, the interval 62–74 is measured, as also the intervals 74–86 and 86–98.

In order to eliminate possible changes in the length of interval $a\,b$ during the measures, due to the proximity of the face of the observer, the same observations are repeated in the reverse order.

The corresponding intervals on Scale B are now measured in the same way, and then the whole operation is repeated, beginning with Scale B and ending with Scale A. Such an operation constitutes a complete set.

The following table contains the result of six *sets* of measures, on six different days, of the excess of the various intervals over the space $a\,b$; these constitute the first series.

As a matter of convenience, we call one Scale A, the other B, and designate our fundamental intervals—

Scale A. 50–62 = α; 62–74 = β; 74–86 = γ; 86–98 = δ.
„ B. 50–62 = α'; 62–74 = β'; 74–86 = γ'; 86–98 = δ'.

FIRST SERIES.

SCALE A				SCALE B			
α	β	γ	δ	α'	β'	γ'	δ'
·2995	·2767	·2832	·2702	·2990	·2897	·2875	·2777
·2925	·2737	·2858	·2702	·2990	·2885	·2877	·2880
·2952	·2755	·2827	·2722	·3042	·2927	·2812	·2825
·2930	·2780	·2867	·2867	·2875	·2950	·2835	·2805
·2950	·2790	·2790	·2775	·2948	·3035	·2830	·2907
·2920	·2652	·2862	·2760	·2920	·2900	·2845	·2870
·2882	·2802	·2872	·2782	·2892	·2937	·2847	·2807
·2860	·2675	·2860	·2867	·2902	·2945	·2875	·2920
·2852	·2718	·2838	·2708	·2895	·2890	·2858	·2768
·2818	·2680	·2770	·2638	·2865	·2790	·2755	·2825
·2840	·2588	·2757	·2647	·2750	·2872	·2805	·2765
·2978	·2743	·2858	·2747	·2900	·2780	·2763	·2773

These figures express the fraction of a revolution by which each division exceeds $a\,b$. Each figure is the mean of 4 measures (8 bisections); so that the table exhibits the result of 768 bisections made on six days.

The mean of these excesses is the amount by which one-fourth of the scale exceeds the distance $a\,b$; and therefore, if we subtract this mean excess from each of the excesses α, β, γ, &c., we obtain the error of the length of each division. The separate error of the length of each division, as deduced from each day's observations, is given in the following table :—

FIRST SERIES.

Scale A					Scale B				
Date	a	β	γ	δ	a'	β'	γ'	δ'	Date
1873, Nov. 11	+·01453	−·00627	+·00303	−·01127	+·00936	−·00054	−·00204	−·00679	Nov. 11, 1873
„ „ 12	+·01035	−·00700	+·00095	−·00430	+·00746	+·00546	−·00604	−·00689	„ 12 „
„ „ 13	+·01226	−·00914	+·00136	−·00449	+·00271	+·00606	−·00694	−·00184	„ 13 „
„ „ 14	+·00460	−·00865	+·00410	−·00005	+·00064	+·00504	−·00296	−·00271	„ 14 „
„ „ 19	+·00830	−·00540	+·00510	−·00800	+·00493	+·00093	−·00242	−·00342	„ 19 „
„ „ 20	+·01391	−·01044	+·00376	−·00724	+·00239	+·00254	−·00171	−·00321	„ 20 „
Mean . .	+·01066	−·00782	+·00305	−·00589	+·00458	+·00325	−·00368	−·00414	Mean
Probable error	±·00103	±·00052	±·00044	±·00106	±·00088	±·00074	±·00061	±·00059	Probable error
Do. in arc .	±0″·026	±0″·013	±0″·011	±0″·027	±0″·023	±0″·019	±0″·016	±0″·015	Do. in arc

The probable errors deduced from the agreement of the various determinations give a mean of ± 0″·019 for the probable error of the determination of the length of each 12-division space.

It was not certain, however, whether this result really represented the true probable error of the determination; the possibilities of unequal temperatures in different parts of the scale, and still more of changes in the value of the distance *a b* from proximity to the observer's face, induced us to undertake another determination of the values of our fundamental spaces.

Another series was therefore made in a similar manner with the first series, except that the observations were begun at δ' of Scale *B* and carried out in the reverse order, and with the micrometer head in the opposite direction.

SECOND SERIES.

Scale A				Scale B			
a	β	γ	δ	a'	β'	γ'	δ'
·2975	·2830	·2925	·2803	·2852	·2900	·2838	·2885
·2960	·2958	·2970	·2865	·2912	·2968	·2838	·2937
·3027	·2878	·2925	·2875	·2975	·2970	·2938	·3018
·3045	·2850	·2983	·2857	·2915	·2950	·2888	·2982
·2818	·2700	·2875	·2652	·2829	·2868	·2743	·2808
·2930	·2730	·2867	·2810	·2938	·2935	·2858	·2783
·2897	·2718	·2835	·2872	·2902	·2840	·2870	·2815
·2973	·2792	·2913	·2888	·2860	·2878	·2805	·2803
·2953	·2743	·2818	·2818	·2885	·2912	·2880	·2790
·2985	·2825	·2930	·2808	·2840	·2858	·2862	·2832
·2885	·2823	·2860	·2820	·2895	·2880	·2900	·2830
·2955	·2825	·2928	·2895	·2885	·2845	·2813	·2838
·3025	·2820	·2888	·2852	·2845	·2903	·2900	·2847
·2937	·2815	·2818	·2860	·2953	·2855	·2795	·2885

Each of these figures is, as before, the result of 4 measures (8 bisections); and the results deduced from each day's work are—

SECOND SERIES.

SCALE A					SCALE B				
Date	a	β	γ	δ	a'	β'	γ'	δ'	Date
1873, Nov. 21	+·00569	−·00166	+·00369	−·00771	−·00094	+·00426	−·00534	+·00201	Nov. 21, 1873
„ „ 24	+·01059	−·00661	+·00239	−·00636	−·00091	+·00054	−·00421	+·00459	„ 24 „
„ „ 25	+·00760	−·00830	+·00735	−·00665	+·00360	+·00570	−·00440	−·00490	„ 25 „
„ Dec. 1	+·00741	−·01059	+·00126	+·00191	+·00347	+·00122	−·00093	−·00378	Dec. 1 „
„ „ 2	+·01090	−·00760	+·00140	−·00470	+·00047	+·00277	+·00137	−·00463	„ 2 „
„ „ 3	+·00461	−·00499	+·00201	−·00164	+·00292	+·00017	−·00043	−·00268	„ 3 „
„ „ 3	+·01045	−·00595	−·00245	−·00205	+·00635	−·00065	−·00380	−·00190	„ 3 „
Mean . .	+·00818	−·00653	+·00224	−·00389	+·00214	+·00200	−·00253	−·00161	Mean
Probable error	±·00064	±·00071	±·00075	±·00088	±·00069	±·00059	±·00064	±·00091	Probable error
Do. in arc .	±0″·016	±0″·018	±0″·019	±0″·023	±0″·018	±0″·015	±0″·016	±0″·024	Do. in arc

This agreement with the first series at the time was considered sufficiently satisfactory, and the next process was to subdivide the 12-division spaces into two parts, each of 6 divisions.

In this operation the webs *c d* were employed, and the excess of the 6-division space over the space *c d* was measured as follows :—

THIRD SERIES.

SCALE A				SCALE B			
a		β		a'		β'	
50–56	56–62	62–68	68–74	50–56	56–62	62–68	68–74
·2030	·1898	·1950	·1658	·1760	·1738	·1745	·1643
·1935	·1860	·1878	·1660	·1782	·1680	·1725	·1745
·1940	·1875	·1870	·1787	·1818	·1680	·1785	·1807
·1928	·1803	·1878	·1805	·1835	·1695	·1847	·1735
γ		δ		γ'		δ'	
72–78	78–86	86–92	92–98	72–78	78–86	86–92	92–98
·1840	·1793	·1860	·1863	·1780	·1775	·1783	·1705
·1906	·1843	·1775	·1907	·1675	·1697	·1765	·1733
·1915	·1763	·1770	·1893	·1712	·1777	·1812	·1753
·1893	·1823	·1802	·1803	·1730	·1685	·1720	·1603

Each figure is here also the result of 4 measures (8 bisections); and the following table shows the result derived from each day's observations for the error of the first half of each fundamental 12-division space, in terms of that space. (This error is, of course, half the difference between the two 6-division spaces.)

THIRD SERIES.

SCALE A

Date	α		β		γ		δ		Date
	50–56	56–62	62–68	68–74	74–80	80–86	86–92	92–98	
1873, Dec. 12	+·00515	−·00517	+·01275	−·01275	+·00275	−·00275	−·00307	+·00307	Dec. 13, 1873
„ „ 17	+·00475	−·00475	+·00390	−·00390	+·00555	−·00555	−·00310	+·00310	„ 15 „
Excess of 1st space	+·00495		+·00832		+·00415		−·00309		Excess of 1st space
Probable error	±·00019		±·00416		±·00094		±·00001		Probable error

SCALE B

Date	α'		β'		γ'		δ'		Date
	50–56	56–62	62–68	68–74	74–80	80–86	86–92	92–98	
1873, Dec. 12	+·00310	−·00310	+·00205	−·00205	−·00042	+·00042	+·00275	−·00275	Dec. 13, 1873
„ „ 17	+·00695	−·00695	+·00225	−·00225	−·00050	+·00050	+·00440	−·00440	„ 15 „
Excess of 1st space	+·00502		+·00215		−·00046		+·00357		Excess of 1st space
Probable error	±·00183		±·00009		±·00003		±·00078		Probable error

With the intention of comparing the lengths of the two scales, as well as of confirming the results derived from the last series, the next series was made as follows :—

c d was compared with the two halves of α, then with the two halves of α', again with the two halves of α', and finally with the two halves of α.

The next day the halves of β and β' were compared, and so on.

A little reflection showed that, so far as the comparison of the scale *A* with the scale *B* was concerned, this series was useless, because it was necessary to assume that the webs *c* and *d* were strictly parallel to each other, a condition not likely to be, and which we found not to be, strictly realised. The series, however, was useful for the subdivision of the fundamental divisions into two halves.

FOURTH SERIES.

SCALE A

α		β		γ		δ	
50–56	56–62	62–68	68–74	74–80	80–86	86–92	92–98
·2003	·1840	·1873	·1683	·1928	·1795	·1793	·1788
·1970	·1812	·1878	·1713	·1910	·1840	·1820	·1838
·1955	·1842	·1910	·1780	·1933	·1865	·1875	·1935
·1920	·1823	·1943	·1835	·1880	·1870	·1848	·1915

SCALE B

α'		β'		γ'		δ'	
50–56	56–62	62–68	68–74	74–80	80–86	86–92	92–98
·1815	·1730	·1703	·1738	·1715	·1693	·1688	·1595
·1680	·1740	·1743	·1738	·1773	·1665	·1695	·1635
·1727	·1740	·1763	·1743	·1720	·1648	·1803	·1743
·1770	·1775	·1763	·1708	·1715	·1695	·1760	·1720

Each figure is here also the result of 4 measures; the results, exhibited as in the Third Series, are—

FOURTH SERIES.

Scale A									
Date	α		β		γ		δ		Date
	50–56	56–62	62–68	68–74	74–80	80–86	86–92	92–98	
1873, Dec. 18	+·00690	−·00690	+·00682	−·00682	+·00508	−·00508	−·00032	+·00032	Jan. 1, 1874
„ „ 27	+·00637	−·00637	+·00695	−·00695	+·00195	−·00195	−·00317	+·00317	„ 5 „
1874, Jan. 1									
Mean . .	+·00664		+·00689		+·00351		−·00174		Mean
Probable error	±·00025		±·00006		±·00150		±·00136		Probable error

Scale B									
Date	α'		β'		γ'		δ'		Date
	50–56	56–62	62–68	68–74	74–80	80–86	86–92	92–98	
1873, Dec. 18	+·00180	−·00180	−·00075	+·00075	−·00175	+·00175	+·00383	−·00383	Jan. 1, 1874
„ „ 27	−·00162	+·00162	+·00188	−·00188	+·00230	−·00230	+·00250	−·00250	„ 5 „
1874, Jan. 1									
Mean . .	+·00009		+·00056		+·00027		+·00316		Mean
Probable error	±·00163		±·00125		±·00194		±·00064		Probable error

It appeared to us now a matter of considerable importance so to arrange the observations for subdividing α, β, &c., into two parts, that we might at the same time check the lengths of the fundamental divisions—that is to say, we might so arrange the series as to find the value of a 6-division space in terms of the whole scale instead of in terms of the fundamental divisions only. For this purpose it was necessary to compare $c\,d$ with each of the eight 6-division spaces of the scale on the same day.

The observations were made precisely as in the First and Second Series, one of the scales only being examined on one day. The following are the excesses of the space $b\,c$ as measured :—

FIFTH SERIES.

Scale A							
50–56	56–62	62–68	68–74	74–80	80–86	86–92	92–98
·1978	·1820	·1910	·1730	·1903	·1795	·1815	·1828
·1940	·1875	·1882	·1725	·1923	·1807	·1825	·1810
·1740	·1680	·1785	·1580	·1815	·1763	·1758	·1740
·1812	·1668	·1847	·1658	·1757	·1705	·1638	·1672

Scale B							
50–56	56–62	62–68	68–74	74–80	80–86	86–92	92–98
·1790	·1743	·1800	·1745	·1753	·1693	·1805	·1780
·1785	·1730	·1733	·1760	·1783	·1657	·1800	·1703
·1898	·1835	·1797	·1698	·1887	·1730	·1945	·1760
·1900	·1833	·1885	·1810	·1763	·1620	·1720	·1697

Each figure is also here the mean of 4 measures (8 bisections). We can from this series first compute the errors of the fundamental divisions α, β, γ, δ, α', β', γ', δ', by adding the sums of the excesses of the two 6-division spaces which compose a fundamental division, and comparing that with one-fourth the sum of the eight observed excesses.

In this way we obtain for the excess of the lengths of α, β, &c.—

FIFTH SERIES.

SCALE A					SCALE B				
Date	α	β	γ	δ	α'	β'	γ'	δ'	Date
1874, Jan. 6	+·00554	−·00361	+·00091	−·00284	+·00082	+·00057	−·00322	+·00182	Jan. 9, 1874
„ „ 7	−·00011	−·00086	+·00339	−·00241	+·00679	−·00011	−·00486	−·00181	„ 10 „
Mean . .	+·00271	−·00224	+·00215	−·00263	+·00381	+·00023	−·00404	+·00001	Mean
Probable error	±·00191	±·00093	±·00083	±·00014	±·00201	±·00023	±·00055	±·00122	Probable error
Do. in arc .	±0″·049	±0″·024	±0″·021	±0″·004	±0″·052	±0″·006	±0″·014	±0″·031	Do. in arc

Instead of deducing the absolute errors of each 6-division space in terms of the scale, we thought it better to deduce the error of each 6-division space in terms of the fundamental division to which it belonged, and use the absolute errors to strengthen the determination of the lengths of the fundamental spaces.

The results of the Fifth Series treated in this way are as follows :—

FIFTH SERIES.

SCALE A

Date	α		β		γ		δ		Date
	50–56	56–62	62–68	68–74	74–80	80–86	86–92	92–98	
1874, Jan. 6	+·00545	−·00545	+·00842	−·00842	+·00560	−·00560	+·00012	−·00012	Jan. 6, 1874
„ „ 7	+·00510	−·00510	+·00985	−·00985	+·00260	−·00260	−·00040	+·00040	„ 7 „
Mean . .	+·00527		+·00914		+·00410		−·00014		Mean
Probable error	±·00012		±·00048		±·00101		±·00018		Probable error

SCALE B

Date	α'		β'		γ'		δ'		Date
	50–56	56–62	62–68	68–74	74–80	80–86	86–92	92–98	
1874, Jan. 9	+·00255	−·00255	+·00070	−·00070	+·00465	−·00465	+·00305	−·00305	Jan. 9, 1874
„ „ 10	+·00325	−·00325	+·00435	−·00435	+·00750	−·00750	+·00520	−·00520	„ 10 „
Mean . .	+·00290		+·00252		+·00608		+·00413		Mean
Probable error	±·00236		±·00123		±·00093		±·00043		Probable error

The errors of the fundamental spaces resulting from this series, though of the same sign, were considerably smaller than those deduced from the examination in spaces of twelve. It was resolved to repeat both operations on a somewhat different plan.

An examination of the detailed observations of the previous series showed that their agreement very much depended on the fact that the observations had been arranged so as tolerably well to eliminate the effects of gradual change in the relative lengths of the space *a b* or *b c* and the scale.

Accordingly in the following series means were taken still more perfectly to carry out this feature, viz. to compare the distance *a b* with each space of one scale, by moving the scale between each measure. Thus it was possible at one sitting to move the scale backwards and forwards sixteen times, comparing the space *a b* first with α, then with β, then with γ, then δ, then with δ again; then γ, β, and α; then α again, then β, and so on.

The following table is the result of this series :—

SIXTH SERIES.

SCALE A				SCALE B			
α	β	γ	δ	α'	β'	γ'	δ'
·2938	·2791	·2920	·2803	·2829	·2804	·2735	·2736
·2934	·2755	·2980	·2865	·2779	·2749	·2660	·2721
·2940	·2769	·2891	·2828	·2792	·2726	·2700	·2716
·2936	·2773	·2919	·2840	·2836	·2765	·2708	·2726
·2883	·2790	·2819	·2758	·2749	·2745	·2690	·2715
·2933	·2712	·2833	·2790	·2825	·2757	·2748	·2745
·2871	·2696	·2838	·2709	·2801	·2843	·2734	·2751
·2875	·2749	·2836	·2698	·2881	·2869	·2786	·2863

Each figure is the mean of 8 measures (16 bisections).

The following are the resulting values of the lengths of α, β, &c. :—

SIXTH SERIES.

SCALE A					SCALE B				
Date	α	β	γ	δ	α'	β'	γ'	δ'	Date
1874, Jan. 15	+·00750	−·00720	+·00570	−·00600	+·00530	+·00280	−·00410	−·00400	Jan. 26, 1874
„ „ 15	+·00505	−·01285	+·00965	−·00185	+·00517	+·00217	−·00673	−·00063	„ 26 „
„ „ 17	+·00830	−·00880	+·00340	−·00290	+·00592	−·00078	−·00338	−·00178	„ 26 „
„ „ 17	+·00690	−·00940	+·00520	−·00270	+·00773	+·00063	−·00507	−·00327	„ 26 „
„ „ 17	+·00705	−·00225	+·00065	−·00545	+·00242	+·00202	−·00348	−·00098	„ 27 „
„ „ 17	+·01155	−·01045	+·00165	−·00275	+·00560	−·00110	−·00210	−·00240	„ 27 „
„ „ 23	+·00925	−·00825	+·00595	−·00695	+·00187	+·00607	−·00483	−·00313	Feb. 2 „
„ „ 23	+·00855	−·00405	+·00465	−·00915	+·00312	+·00192	−·00638	+·00132	„ 2 „
Mean . .	+·00802	−·00791	+·00461	−·00472	+·00464	+·00172	−·00451	−·00186	Mean
Probable error	±·00046	±·00081	±·00067	±·00061	±·00047	±·00054	±·00037	±·00041	Probable error
Do. in arc .	±0″·012	±0″·021	±0″·017	±0″·016	±0″·012	±0″·014	±0″·010	±0″·011	Do. in arc

These results are in very satisfactory agreement with those derived from the First and Second Series.

In a manner precisely similar the space *b c* was compared with the 6-division spaces as follows: —

SEVENTH SERIES.

SCALE A							
a		*β*		*γ*		*δ*	
50–56	56–62	62–68	68–74	74–80	80–86	86–92	92–98
·1882	·1865	·1735	·1720	·1860	·1813	·1723	·1850
·1770	·1697	·1700	·1638	·1745	·1645	·1655	·1758
·1773	·1747	·1683	·1687	·1883	·1715	·1757	·1860
·1863	·1745	·1775	·1627	·1783	·1697	·1695	·1802
·1800	·1687	·1705	·1645	·1860	·1730	·1645	·1700
·1825	·1737	·1638	·1657	·1835	·1738	·1770	·1810
·1835	·1728	·1667	·1583	·1820	·1760	·1683	·1795
·1865	·1622	·1745	·1623	·1792	·1710	·1610	·1778
SCALE B							
α′		*β′*		*γ′*		*δ′*	
50–56	56–62	62–68	68–74	74–80	80–86	86–92	92–98
·1752	·1695	·1735	·1655	·1788	·1670	·1747	·1717
·1698	·1650	·1743	·1683	·1720	·1585	·1755	·1693
·1873	·1763	·1765	·1735	·1890	·1765	·1800	·1828
·1763	·1753	·1800	·1828	·1812	·1693	·1760	·1720
·1775	·1713	·1758	·1792	·1800	·1718	·1730	·1672
·1735	·1683	·1698	·1670	·1732	·1623	·1755	·1658
·1648	·1663	·1678	·1713	·1618	·1573	·1645	·1593
·1670	·1648	·1645	·1593	·1633	·1513	·1620	·1555

Each figure is the mean of 4 measures (8 bisections).

Finding in the first place the lengths of *α*, *β*, *γ*, &c. (as in the Fifth Series), we have the following results :—

SEVENTH SERIES.

SCALE A					SCALE B				
Date	*α*	*β*	*γ*	*δ*	*α′*	*β′*	*γ′*	*δ′*	Date
	+ ·00500	− ·00552	+ ·00050	− ·00050	− ·00066	− ·00014	− ·00146	+ ·00226	
	+ ·00262	− ·00627	+ ·00137	+ ·00227	+ ·00053	− ·00007	+ ·00073	− ·00119	
	+ ·00259	− ·00751	+ ·00344	− ·00051	+ ·00070	+ ·00100	− ·00013	− ·00157	
	+ ·00365	− ·00715	+ ·00445	− ·00095	+ ·00355	+ ·00355	− ·00525	− ·00185	
Mean . .	+ ·00346	− ·00661	+ ·00244	+ ·00008	+ ·00103	+ ·00109	− ·00152	− ·00059	Mean
Probable error	± ·00038	± ·00030	± ·00072	± ·00050	± ·00060	± ·00058	± ·00087	± ·00065	Probable error
Do. in arc .	± 0″·010	± 0″·008	± 0″·018	± 0″·013	± 0″·015	± 0″·015	± 0″·022	± 0″·017	Do. in arc

And for the subdivision of α, β, γ, δ, &c., into two parts we have—

SEVENTH SERIES.

SCALE A

Date	α		β		γ		δ		Date
	$\frac{a^1}{2}$	$\frac{a^2}{2}$	$\frac{\beta^1}{2}$	$\frac{\beta^2}{2}$	$\frac{\gamma^1}{2}$	$\frac{\gamma^2}{2}$	$\frac{\delta^1}{2}$	$\frac{\delta^2}{2}$	
1874, Feb. 2	+·00225	−·00225	+·00192	−·00192	+·00367	−·00367	−·00575	+·00575	Feb. 2, 1874
„ „ 4	+·00360	−·00360	+·00360	−·00360	+·00635	−·00635	−·00525	+·00525	„ 4 „
„ „ 5	+·00502	−·00502	+·00102	−·00102	+·00567	−·00567	−·00237	+·00237	„ 5 „
„ „ 6	+·00875	−·00875	+·00515	−·00515	+·00355	−·00355	−·00700	+·00700	„ 6 „
Mean . .	+·00490		+·00292		+·00481		−·00509		Mean
Probable error	±·00094		±·00062		±·00071		±·00065		Probable error
Do. in arc .	±0″·024		±0″·016		±0″·012		±0″·017		Do. in arc

SCALE B

Date	α'		β'		γ'		δ'		Date
	$\frac{a^{1\prime}}{2}$	$\frac{a^{2\prime}}{2}$	$\frac{\beta^{1\prime}}{2}$	$\frac{\beta^{2\prime}}{2}$	$\frac{\gamma^{1\prime}}{2}$	$\frac{\gamma^{2\prime}}{2}$	$\frac{\delta^{1\prime}}{2}$	$\frac{\delta^{2\prime}}{2}$	
1874, Feb. 10	+·00262	−·00262	+·00350	−·00350	+·00632	−·00632	+·00230	−·00230	Feb. 10, 1874
„ „ 11	+·00380	−·00380	+·00005	−·00005	+·00610	−·00610	+·00030	−·00030	„ 11 „
„ „ 12	+·00285	−·00285	−·00015	−·00015	+·00477	−·00477	+·00387	−·00387	„ 12 „
„ „ 13	+·00017	−·00017	+·00042	−·00042	+·00562	−·00562	+·00292	−·00292	„ 13 „
Mean . .	+·00236		+·00095		+·00570		+·00235		Mean
Probable error	±·00053		±·00057		±·00024		±·00051		Probable error
Do. in arc .	±0″·014		±0″·015		±0″·006		±0″·013		Do. in arc

The next step is to subdivide each of the 6-division spaces into two spaces of three divisions each.

For this purpose the space *c f* was compared twice with 50–53, then twice with 53–56, then twice again with 53–56, and then again with 50–53.

This operation was repeated three times, making 12 measures in all (24 bisections) of each division. Two 6-division spaces were subdivided in this way at each sitting.

A second series was then made, in which *f d* was compared with the 3-division spaces in the same way.

The following table shows the resulting excesses of the 3-division spaces as measured :—

EIGHTH SERIES.

SCALE A

α				β				γ				δ			
50–56		56–62		62–68		68–74		74–80		80–86		86–92		92–98	
50–53	53–56	56–59	59–62	62–65	65–68	68–71	71–74	74–77	77–80	80–83	83–86	86–89	89–92	92–95	95–98
·095	·098	·086	·090	·092	·101	·096	·077	·097	·083	·080	·078	·071	·081	·069	·076
·096	·093	·084	·099	·092	·090	·090	·089	·082	·091	·081	·075	·060	·069	·072	·076
·096	·086	·085	·089	·090	·086	·099	·088	·092	·091	·075	·083	·065	·079	·070	·074
·014	·088	·088	·094	·074	·078	·076	·073	·078	·073	·071	·072	·078	·088	·069	·076
·090	·093	...	...	·074	·083	·082	·062	·078	·074	·071	·073	·082	·087	·073	·072
·090	·081	·084	·087	·078	·083	·076	·069	·081	·074	·077	·073	·077	·081	·070	·075

SCALE B

α'				β'				γ'				δ'			
50–56		56–62		62–68		68–74		74–80		80–86		86–92		92–98	
50–53	53–56	56–59	59–62	62–65	65–68	68–71	71–74	74–77	77–80	80–83	83–86	86–89	89–92	92–95	95–98
·070	·067	·061	·059	·065	·070	·060	·063	·075	·084	·072	·068	·078	·080	·075	·071
·059	·064	·061	·059	·060	·065	·055	·064	·066	·082	·074	·069	·080	·074	·069	·067
·066	·065	·067	·057	·065	·064	·055	·072	·069	·074	·076	·076	·072	·077	·072	·062
·063	·075	·066	·064	·061	·070	·063	·072	·073	·087	·072	·068	·075	·074	·073	·067
·064	·067	·063	·057	·075	·073	·072	·076	·076	·082	·074	·076	·065	·079	·074	·062
·063	·066	·063	·059	·072	·068	·065	·076	·075	·086	·077	·066	·069	·072	·064	·068

Each figure is the mean of 4 measures (8 bisections).

The results for excess of the first three divisions over the half of each 6-division space derived from these measures is given below :—

EIGHTH SERIES.

SCALE A

February 16, 1874				February 17, 1874				February 19, 1874				February 19 and 20, 1874			
$\frac{\alpha^1}{2}$		$\frac{\alpha^2}{2}$		$\frac{\beta^1}{2}$		$\frac{\beta^2}{2}$		$\frac{\gamma^1}{2}$		$\frac{\gamma^2}{2}$		$\frac{\delta^1}{2}$		$\frac{\delta^2}{2}$	
50–53	53–56	56–59	59–62	62–65	65–68	68–71	71–74	74–77	77–80	80–83	83–86	86–89	89–92	92–95	95–98
+ ·0016	− ·0016	− ·0038	+ ·0038	− ·0005	+ ·0005	+ ·0053	− ·0053	+ ·0010	− ·0010	+ ·0000	− ·0000	− ·0055	+ ·0055	− ·0025	+ ·0025
+ ·0037	− ·0037	− ·0022	+ ·0022	− ·0030	+ ·0030	+ ·0050	− ·0050	+ ·0025	− ·0025	+ ·0001	− ·0001	− ·0032	+ ·0032	− ·0018	+ ·0018
+ ·00265		− ·00300		− ·00175		+ ·00515		+ ·00175		+ ·00005		− ·00435		− ·00215	
± ·00071		± ·00054		± ·00084		± ·00010		± ·00051		± ·00003		± ·00078		± ·00024	
±0″·018		±0″·014		±0″·022		±0″·003		±0″·013		+0″·001		±0″·020		±0″·006	

EIGHTH SERIES—*continued.*

SCALE B

February 20 and 21, 1874				February 21, 1874				February 27, 1874				February 28, 1874			
$\frac{\alpha^{1\prime}}{2}$		$\frac{\alpha^{2\prime}}{2}$		$\frac{\beta^{1\prime}}{2}$		$\frac{\beta^{2\prime}}{2}$		$\frac{\gamma^{1\prime}}{2}$		$\frac{\gamma^{2\prime}}{2}$		$\frac{\delta^{1\prime}}{2}$		$\frac{\delta^{2\prime}}{2}$	
50–53	53–56	56–59	59–62	62–65	65–68	68–71	71–74	74–77	77–80	80–83	83–86	86–89	89–92	92–95	95–98
−·00015	+·00015	+·0024	−·0024	−·0015	+·0015	−·0048	+·0048	−·0050	+·0050	+·0015	−·0015	−·0002	+·0002	+·0027	−·0027
−·00300	+·0030	+·0020	−·0020	−·0005	+·0005	−·0040	+·0040	−·0052	+·0052	+·0022	−·0022	−·0027	+·0027	−·0023	+·0023
−·00157		+·00220		−·00100		−·00440		−·00510		+·00185		−·00145		+·00250	
±·00096		±·00013		±·00034		±·00027		±·00007		±·00024		±·00084		±·00013	
±0″·025		±0″·003		±0″·009		±0″·006		±0″·002		±0″·006		±0″·022		±0″·033	

To find the errors of the lengths of the single divisions as compared with the 3-division spaces already ascertained, the screw head having been set at 0, the division 50 was brought by the slow motion to bisection with the central wires *f*. The bisection was perfected by a motion of the micrometer, and the head was read off; then, without moving the scale, the division 51 was bisected by the micrometer. This bisection was again repeated, then 50 again bisected. The scale was now moved till 51 was bisected, and a similar measurement of the space 51–52 was made. The space 52–53 was measured in the same way. Then the operation was repeated backwards, then again in the original direction, and finally backwards: so that each of the three single-division spaces was measured eight times *by the same part of the screw.*

The mean of these measures being the value of one-third of the 3-division space 50–53, the excess of each division over this amount was the error of the length of that division in terms of that 3-division space. The same operation was carried out for each 3-division space on the fundamental scales, and the following table exhibits the results derived from the complete operation :—

NINTH SERIES.

SCALE A

	50–53			53–56			56–59			59–62		
α	50–51	51–52	52–53	53–54	54–55	55–56	56–57	57–58	58–59	59–60	60–61	61–62
	−·0003	−·0024	+·0027	−·0036	+·0043	−·0007	−·0014	+·0066	−·0052	+·0082	−·0104	+·0022
	62–65			**65–68**			**68–71**			**71–74**		
β	62–63	63–64	64–65	65–66	66–67	67–68	68–69	69–70	70–71	71–72	72–73	73–74
	−·0015	−·0034	+·0049	−·0024	+·0006	+·0018	+·0041	+·0009	−·0050	−·0017	−·0018	+·0035
	74–77			**77–80**			**80–83**			**83–86**		
γ	74–75	75–76	76–77	77–78	78–79	79–80	80–81	81–82	82–83	83–84	84–85	85–86
	−·0011	−·0035	+·0047	−·0022	+·0022	±·0000	+·0009	−·0026	+·0017	+·0012	−·0010	−·0002
	86–89			**89–92**			**92–95**			**95–98**		
δ	86–87	87–88	88–89	89–90	90–91	91–92	92–93	93–94	94–95	95–96	96–97	97–98
	−·0002	−·0032	+·0034	−·0027	+·0073	−·0046	−·0021	+·0002	+·0019	·0010	+·0011	−·0001

NINTH SERIES—*continued.*

SCALE B

	50–53			53–56			56–59			59–62		
α'	50–51	51–52	52–53	53–54	54–55	55–56	56–57	57–58	58–59	59–60	60–61	61–62
	+·0013	−·0040	+·0027	−·0008	−·0008	+·0016	+·0002	−·0100	+·0098	+·0023	−·0071	+·0048
	62–65			65–68			68–71			71–74		
β'	62–63	63–64	64–65	65–66	66–67	67–68	68–69	69–70	70–71	71–72	72–73	73–74
	+·0033	−·0050	+·0016	+·0008	−·0070	+·0062	+·0028	−·0041	+·0013	+·0018	−·0048	+·0029
	74–77			77–80			80–83			83–86		
γ'	74–75	75–76	76–77	77–78	78–79	79–80	80–81	81–82	82–83	83–84	84–85	85–86
	−·0021	+·0040	−·0020	−·0043	+·0065	−·0022	+·0034	−·0003	−·0031	−·0048	+·0078	−·0030
	86–89			89–92			92–95			95–96		
δ'	86–87	87–88	88–89	89–90	90–91	91–92	92–93	93–94	94–95	95–96	96–97	97–98
	+·0050	−·0003	−·0047	+·0091	−·0020	−·0071	+·0027	−·0051	+·0024	−·0025	+·0095	−·0070

Each figure is the result of 8 measures (16 bisections).

The next step was to extend the investigation of the errors of division beyond the normal scale.

The plan adopted was as follows :—

The space *c d* was compared with the first 6-division interval beyond the normal scale 98–104, and the excess of that space over *c d* measured as in former operations ; then *c d* was compared with 92–98, then *c d* was compared with 86–92, then again with 98–104, then again with 98–104, then with 80–86, and so on, till the 98–104 had been compared twice with each of the eight 6-division spaces of Scale *A* ; then the operation was repeated backwards in the reverse order.

It is obvious that we obtain from such a series not only a very exact determination of the value of the newly investigated space, as compared with one-eighth of the fundamental scale, but also a redetermination of the errors of the relative lengths of the eight components of the fundamental scale, since we compare each directly with the same space.

The following table (Table I., Tenth Series) gives the various measures of the excess of the compared space over *c d*.

Each figure given in the column 'Scale *A*' or 'Scale *B*' is the mean of 4 measures of the excess of the 6-division interval measured over *c d*—the interval so measured being indicated in the left-hand column. The figures in the immediately adjacent column are the corresponding excess of the investigated space, derived from two measures immediately before and two immediately after the corresponding measures of the standard scale.

It is evident that the excess of the mean of the right-hand column over the mean of the left-hand column is the excess of the investigated space over one-eighth of the fundamental scale. Its value is entered in the table.

TENTH SERIES. TABLE I.

SCALE A

Compared space	Scale A	98–104	Scale A	104–110	Scale A	110–116	Scale A	116–122	Scale A	122–128	Scale A	128–134	Scale A	134–140	Scale A	140–146
50–56	·1715	·1638	·1650	·1545	·1720	·1520	·1745	·1655	·1618	·1733	·1643	·1768	·1678	·1703	·1615	·1533
56–62	·1640	·1668	·1758	·1515	·1573	·1543	·1685	·1618	·1580	·1748	·1653	·1778	·1588	·1675	·1683	·1570
62–68	·1633	·1610	·1625	·1548	·1620	·1588	·1578	·1655	·1633	·1723	·1615	·1718	·1633	·1653	·1598	·1530
68–74	·1523	·1553	·1430	·1580	·1455	·1585	·1490	·1608	·1533	·1758	·1403	·1693	·1580	·1655	·1538	·1553
74–80	·1678	·1635	·1620	·1615	·1675	·1623	·1655	·1733	·1643	·1755	·1548	·1675	·1600	·1668	·1708	·1635
80–86	·1560	·1573	·1623	·1583	·1468	·1555	·1560	·1668	·1490	·1673	·1538	·1700	·1515	·1653	·1510	·1578
86–92	·1635	·1628	·1620	·1603	·1548	·1523	·1580	·1713	·1563	·1750	·1515	·1655	·1598	·1643	·1718	·1595
92–98	·1475	·1663	·1555	·1668	·1518	·1568	·1573	·1700	·1535	·1750	·1555	·1675	·1488	·1685	·1558	·1548
Mean .	·16074	·16210	·15876	·15821	·15721	·15631	·16083	·16688	·15744	·17363	·15587	·17040	·15600	·16669	·16160	·15677
Excess of investigated space over $\frac{1}{8}$th of Scale A	+ ·00136		− ·00055		− ·00090		+ ·00605		+ ·01619		+ ·01453		+ ·01069		− ·00483	

Compared space	Scale A	2–8	Scale A	8–14	Scale A	14–20	Scale A	20–26	Scale A	26–32	Scale A	32–38	Scale A	38–44	Scale A	44–50
50–56	·1803	·1833	·1770	·1743	·1800	·1815	·1788	·1745	·1778	·1690	·1788	·1713	·1693	·1608	·1798	·1745
56–62	·1753	·1858	·1820	·1785	·1728	·1843	·1785	·1763	·1785	·1678	·1683	·1708	·1708	·1605	·1805	·1803
62–68	·1740	·1870	·1775	·1733	·1690	·1853	·1698	·1760	·1805	·1775	·1745	·1745	·1718	·1655	·1763	·1843
68–74	·1600	·1883	·1533	·1805	·1623	·1858	·1648	·1705	·1495	·1655	·1510	·1700	·1585	·1663	·1613	·1810
74–80	·1833	·1930	·1730	·1698	·1803	·1815	·1680	·1680	·1595	·1668	·1718	·1695	·1713	·1660	·1730	·1830
80–86	·1690	·1948	·1675	·1835	·1693	·1870	·1685	·1818	·1670	·1660	·1665	·1648	·1623	·1688	·1633	·1790
86–92	·1720	·1930	·1690	·1870	·1743	·1830	·1733	·1768	·1655	·1648	·1778	·1750	·1648	·1678	·1630	·1775
92–98	·1758	·1905	·1630	·1718	·1645	·1823	·1568	·1708	·1645	·1703	·1735	·1670	·1593	·1565	·1675	·1775
Mean .	·17371	·18946	·17029	·17734	·17156	·18384	·16981	·17434	·16785	·16846	·17027	·17036	·16601	·16403	·17059	·17974
Excess of investigated space over $\frac{1}{8}$th of Scale A	+ ·01575		+ ·00705		+ ·01228		+ ·00453		+ ·00061		+ ·00009		− ·00198		+ ·00915	

TENTH SERIES. TABLE I.

SCALE B

Compared space	Scale B	98–104	Scale B	104–110	Scale B	110–116	Scale B	116–122	Scale B	122–128	Scale B	128–134	Scale B	134–140	Scale B	140–146
50–56	·1858	·1825	·1928	·1915	·1855	·1873	·1858	·1910	·1943	·1943	·1830	·1865	·1788	·2020	·1840	·1845
56–62	·1800	·1703	·1940	·1895	·1795	·1890	·1923	·1988	·1910	·1995	·1873	·1785	·1945	·1963	·1818	·1745
62–68	·1760	·1718	·1973	·1965	·1920	·1825	·1925	·1920	·1928	·1988	·1883	·1858	·1903	·2003	·1800	·1720
68–74	·1755	·1818	·1855	·1953	·1865	·1878	·1883	·1908	·1920	·1913	·1845	·1898	·1798	·1975	·1656	·1795
74–80	·1893	·1823	·1930	·1993	·2033	·1823	·1928	·1908	·1983	·1965	·1798	·1848	·1880	·1938	·1763	·1815
80–86	·1725	·1818	·1875	·1978	·1728	·1885	·1813	·1870	·1855	·1995	·1820	·1813	·1823	·1980	·1648	·1728
86–92	·1700	·1928	·1910	·1968	·1780	·1810	·1775	·1970	·1908	·2008	·1875	·1820	·1895	·1960	·1648	·1753
92–98	·1855	·1863	·1910	·1978	·1715	·1800	·1888	·1930	·2000	·1983	·1923	·1835	·1928	·2003	·1728	·1783
Mean .	·17932	·18120	·19151	·19556	·18364	·18480	·18741	·19255	·19309	·19738	·18559	·18403	·18700	·19803	·17369	·17739
Excess of investigated space over $\frac{1}{8}$th of Scale A	+ ·00188		+ ·00405		+ ·00116		+ ·00514		+ ·00429		− ·00156		+ ·01103		+ ·00361	

TENTH SERIES. TABLE I.—*continued.*

Compared space	Scale B	2–8	Scale B	8–14	Scale B	14–20	Scale B	20–26	Scale B	26–32	Scale B	32–38	Scale B	38–44	Scale B	44–50
50–56	·1893	·1765	·1763	·1828	·1823	·1923	·1860	·1818	·1733	·1785	·1798	·1640	·1810	·1930	·1988	·1958
56–62	·1775	·1908	·1773	·1830	·1813	·1953	·1823	·1855	·1790	·1768	·1798	·1695	·1868	·1843	·1995	·1975
62–68	·1868	·1933	·1738	·1785	·1795	·1918	·1883	·1843	·1780	·1823	·1823	·1640	·1830	·1913	·1998	·2028
68–74	·1773	·1888	·1720	·1770	·1753	·1940	·1878	·1885	·1755	·1865	·1780	·1663	·1835	·1843	·1903	·1923
74–80	·1868	·1808	·1740	·1743	·1903	·2000	·1905	·1853	·1835	·1928	·1773	·1768	·1810	·1820	·2155	·1950
80–86	·1698	·1953	·1698	·1810	·1758	·1928	·1740	·1795	·1680	·1913	·1710	·1688	·1795	·1938	·1968	·1938
86–92	·1740	·1873	·1713	·1763	·1773	·1948	·1755	·1843	·1720	·1838	·1805	·1625	·1860	·1923	·1985	·1963
92–98	·1778	·1820	·1730	·1805	·1835	·1970	·1858	·1813	·1780	·1783	·1815	·1653	·1885	·1835	·1983	·1975
Mean	·17991	·18685	·17344	·17918	·18066	·19475	·18378	·18382	·17591	·18378	·17858	·16715	·18366	·18806	·19969	·19638
Excess of investigated space over ⅛th of Scale B	+ ·00694		+ ·00574		+ ·01409		+ ·00004		+ ·00788		− ·01163		+ ·00440		− ·00331	

If, now, each of the excesses of the compared division is diminished by the excess of that division over one-eighth of Scale *A*, and then the amount so found is subtracted from the measured excess of Scale *A*, we shall get the excess of that division of Scale *A* over one-eighth of Scale *A*. In this way Tenth Series, Table II., is found.

At the bottom of the Tenth Series, Table II., is entered half the excess of the first over the second 6-division space of each of the fundamental spaces α, β, γ, &c.

TENTH SERIES. TABLE II.

SCALE A								
By comparison with	α		β		γ		δ	
	50–56	56–62	62–68	68–74	74–80	80–86	86–92	92–98
2–8	+ ·01275	+ ·00525	+ ·00275	− ·01255	+ ·00605	− ·01005	− ·00525	+ ·00105
8–14	+ ·00975	+ ·01055	+ ·01125	− ·02015	+ ·01025	− ·00895	− ·01095	− ·00175
14–20	+ ·01078	+ ·00078	− ·00402	− ·01122	+ ·01108	− ·00542	+ ·00358	− ·00552
20–26	+ ·00883	+ ·01673	− ·00167	− ·00117	+ ·00453	− ·00877	+ ·00103	− ·00947
26–32	+ ·00941	+ ·01131	+ ·00361	− ·01539	− ·00669	+ ·00161	+ ·00131	− ·00521
32–38	+ ·00759	− ·00241	+ ·00009	− ·01891	+ ·00239	+ ·00179	+ ·00289	+ ·00659
38–44	+ ·00652	+ ·00832	+ ·00432	− ·00978	+ ·00322	− ·00848	− ·00498	+ ·00082
44–50	+ ·01445	+ ·00935	+ ·00115	− ·01055	− ·00085	− ·00735	− ·00535	− ·00085
98–104	+ ·00906	− ·00144	+ ·00366	− ·00164	+ ·00566	+ ·00006	+ ·00206	− ·01744
104–110	+ ·00995	+ ·00575	+ ·00715	− ·01555	− ·00005	+ ·00345	+ ·00115	− ·01185
110–116	+ ·01910	+ ·00210	+ ·00230	− ·01390	+ ·00430	− ·00960	+ ·00160	− ·00590
118–122	+ ·01505	+ ·01275	− ·00165	− ·00575	− ·00175	− ·00475	− ·00725	− ·00665
122–128	+ ·00469	− ·00061	+ ·00719	− ·00631	+ ·00499	− ·00211	− ·00251	− ·00531
128–134	+ ·00203	+ ·00503	+ ·00423	− ·01447	+ ·00183	− ·00167	+ ·00053	+ ·00253
134–140	+ ·00819	+ ·00199	+ ·00869	− ·01681	+ ·00389	− ·00311	+ ·00619	− ·00901
140–146	+ ·00337	+ ·00647	+ ·00197	− ·00633	+ ·00247	− ·01163	+ ·00749	− ·00383
Mean . .	+ ·00947	+ ·00513	+ ·00319	− ·01128	+ ·00321	− ·00469	− ·00053	− ·00446
Probable error	± ·00074	± ·00094	± ·00068	± ·00097	± ·00074	± ·00081	± ·00085	± ·00100
Do. in arc .	± 0″·019	± 0″·024	± 0″·018	± 0″·025	± 0″·019	± 0″·021	± 0″·022	± 0″·026
Excess of the lesser division	+ ·00217		+ ·00724		+ ·00395		+ ·00198	

TENTH SERIES. TABLE II.—*continued.*

SCALE B								
By comparison with	α'		β'		γ'		δ'	
	50–56	56–62	62–68	68–74	74–80	80–86	86–92	92–98
2–8	+·01974	−·00636	+·00044	−·00456	+·01294	−·01856	−·00636	+·00274
8–14	−·00076	+·00004	+·00104	+·00074	+·00544	−·00546	+·00074	−·00176
14–20	+·00409	+·00009	+·00179	−·00461	+·00439	−·00291	−·00341	+·00059
20–26	+·00424	−·00316	+·00404	−·00066	+·00524	−·00546	−·00876	+·00454
26–32	+·00268	+·01008	+·00358	−·00312	−·00142	−·01542	−·00392	+·00758
32–38	+·00417	−·00133	+·00667	+·00007	−·01113	−·00943	+·00637	+·00457
38–44	−·00760	+·00690	−·00390	+·00360	+·00340	−·00990	−·00190	+·00940
44–50	−·00031	−·00131	−·00631	−·00531	+·01719	−·00031	−·00111	−·00251
98–104	+·00518	+·01158	+·00608	−·00442	+·00888	−·00742	−·02092	+·00108
104–110	+·00535	+·00855	+·00485	−·00575	−·00225	−·00625	−·00175	−·00275
110–116	−·00064	−·00834	+·01066	−·00014	+·02216	−·01454	−·00184	−·00734
116–122	−·00006	−·00136	+·00564	+·00264	+·00714	−·00056	−·01436	+·00094
122–128	+·00429	−·00421	−·00171	+·00499	+·00609	−·00971	−·00571	+·00599
128–134	−·00506	+·00724	+·00094	−·00686	−·00656	−·00086	+·00394	+·00724
134–140	−·01217	+·00923	+·00103	−·00667	+·00523	−·00467	+·00453	+·00353
140–146	+·00311	+·01091	+·01161	−·01089	−·00159	−·00439	−·00689	−·00189
Mean . .	+·00164	+·00241	+·00291	−·00256	+·00470	−·00724	−·00384	+·00200
Probable error	±·00117	±·00112	±·00081	±·00072	±·00142	±·00091	±·00117	±·00076
Do. in arc .	±0″·030	±0″·029	±0″·021	±0″·019	±0″·036	±0″·024	±0″·030	±0″·020
Excess of the lesser division	−·00039		+·00274		+·00597		−·00292	

Adding together the two excesses composing the fundamental spaces α, β, γ, &c., we obtain the Tenth Series, Table III., which is an independent determination of the excesses of these divisions.

TENTH SERIES. TABLE III.

By comparison with	α	β	γ	δ	α'	β'	γ'	δ'
2–8	+·01800	−·00980	−·00400	−·00420	+·01338	−·00412	−·00562	−·00362
8–14	+·02030	−·00890	+·00130	−·01260	−·00072	+·00178	−·00002	−·00102
14–20	+·01156	−·01524	+·00566	−·00194	+·00418	−·00292	+·00148	−·00282
20–26	+·01556	−·00284	−·00424	−·00844	+·00108	+·00338	−·00022	−·00422
26–32	+·02072	−·01178	−·00508	−·00390	+·01276	+·00046	−·01684	+·00366
32–38	+·00518	−·01882	+·00418	+·00948	+·00284	+·00674	−·02056	+·01094
38–44	+·01484	−·00546	−·00526	−·00416	−·00070	−·00030	−·00650	+·00750
44–50	+·02380	−·00940	−·00820	−·00620	−·00162	−·01162	+·01688	−·00362
98–104	+·00762	+·00202	+·00572	−·01538	+·01676	+·00166	+·00146	−·01984
104–110	+·01570	−·00840	+·00340	−·01070	+·01390	−·00090	−·00850	−·00450
110–116	+·02120	−·01160	−·00530	−·00430	−·00808	+·01052	+·00762	−·00918
116–122	+·02780	−·00740	−·00650	−·01390	−·00142	+·00828	+·00658	−·01342
122–128	+·00408	+·00088	+·00288	−·00782	+·00008	+·00328	−·00362	+·00028
128–134	+·00706	−·01024	+·00016	+·00306	+·00218	−·00592	−·00742	+·01118
134–140	+·01018	−·00812	+·00078	−·00282	−·00294	−·00564	+·00056	+·00806
140–146	+·00984	−·00436	−·00916	+·00364	+·01402	+·00072	−·00598	−·00878
Mean . .	+·01459	−·00809	−·00148	−·00501	+·00405	+·00034	−·00254	−·00184
Probable error	±·00119	±·00094	±·00087	±·00112	±·00131	±·00095	±·00154	±·00147
Do. in arc .	±0″·029	±0″·024	±0″·022	±0″·028	±0″·033	±0″·024	±0″·039	±0″·037

It still remains to ascertain the errors of the single-division spaces beyond the normal scales.

For this it was necessary to devise some method sufficiently exact, yet not too laborious, as the number of spaces to be investigated amounted to 192.

By the Tenth Series the error of the length of each 6-division space was ascertained, so the most direct method was to compare each of the six single divisions in a 6-division space with the same two revolutions of the micrometer screw.

To secure quickly a sufficient number of bisections, the first division of a 6-division space was bisected by each of the three double webs of fig. 5 ; the next space was then bisected by the same three double webs ;[1] the whole operation was then repeated in the reverse order, and thus six measures of the space secured in terms of the screw.

The next division was now brought up, and measured in the same way by the same part of the screw, and so on till each of the six components of the 6-division space had been measured twice by each of the three double webs ; then the whole operation was repeated backwards, so that the final result for the length of each 6-division space depends on 12 measures (24 bisections) so arranged as to eliminate errors due to gradual change of the relative positions of the microscope and scale, and of the value of the run of the micrometer screw, and also errors of the screw itself.

The Eleventh Series, Table I., contains the result of the observations made in this way. The length of each division, given in terms of the screw, is the mean of 4 measures (8 bisections) ; the three lines show the separate results derived from measures by each of the three double webs.

The last column is the mean length or true value of one-sixth of the 6-division space measured. If the measures were perfect, and the screw had only a periodic error which had the same value for each revolution, then all these means would be alike.

As we afterwards found, however, the periodic error of the screw is not the same for each revolution, and requires for its expression terms depending on the distance measured from zero ; hence the mean length is not necessarily the same for the measures made with each double web, since they are made by different parts of the screw.

ELEVENTH SERIES. TABLE I.

SCALE A.

2–3	3–4	4–5	5–6	6–7	7–8	Mean
1·9980	1·9975	2·0015	2·0022	1·9987	2·0033	2·0002
2·0042	2·0050	2·0017	1·9978	2·0008	2·0078	2·0029
2·0100	2·0035	1·9977	2·0080	2·0035	2·0002	2·0038

[1] There are, of course, in all only four webs, but these form three spaces, $\overset{a\,b\,c}{|\,|\,|\,|}\ a\,b\,c$, in the centre of which the image of the division can be placed, or bisected according to the definition we have adopted at p. 12, note 1.

ELEVENTH SERIES. TABLE I.—*continued.*

8–9	9–10	10–11	11–12	12–13	13–14	Mean
1·9890	1·9987	1·9940	1·9975	2·0032	2·0033	1·9976
1·9877	2·0055	2·0050	1·9998	2·0120	1·9980	1·9997
1·9948	2·0000	1·9945	2·0015	2·0082	1·9910	1·9983

14–15	15–16	16–17	17–18	18–19	19–20	Mean
1·9988	2·0052	2·0058	1·9917	2·0017	2·0065	2·0016
2·0027	1·9987	2·0088	1·9863	2·0047	2·0082	2·0016
2·0037	1·9993	2·0085	1·9895	1·9955	2·0128	2·0016

20–21	21–22	22–23	23–24	24–25	25–26	Mean
1·9957	2·0028	2·0067	1·9893	1·9975	1·9965	1·9981
2·0053	2·0002	2·0080	1·9867	1·9983	1·9940	1·9988
2·0050	1·9977	2·0060	1·9985	1·9932	2·0005	2·0002

26–27	27–28	28–29	29–30	30–31	31–32	Mean
2·0003	1·9925	1·9955	1·9962	2·0045	1·9905	1·9966
1·9905	1·9920	1·9968	1·9985	2·0042	1·9835	1·9943
1·9978	1·9937	1·9933	1·9918	2·0063	1·9883	1·9952

32–33	33–34	34–35	35–36	36–37	37–38	Mean
1·9972	1·9973	1·9898	1·9960	1·9897	1·9972	1·9945
1·9955	2·0002	1·9997	1·9912	1·9925	1·9942	1·9956
1·9903	1·9948	1·9947	1·9930	1·9970	1·9905	1·9934

38–39	39–40	40–41	41–42	42–43	43–44	Mean
1·9882	1·9990	1·9912	1·9978	1·9890	1·9925	1·9930
1·9990	2·0045	1·9855	1·9917	1·9937	1·9947	1·9949
2·0007	2·0100	1·9935	1·9928	1·9993	1·9939	1·9984

44–45	45–46	46–47	47–48	48–49	49–50	Mean
1·9983	1·9950	1·9950	1·9885	1·9992	2·0043	1·9967
2·0085	1·9940	1·9935	1·9928	1·9945	2·0063	1·9983
1·9985	1·9948	1·9962	1·9992	1·9912	1·9993	1·9965

98–99	99–100	100–101	101–102	102–103	103–104	Mean
1·9970	1·9950	1·9873	1·9995	1·9793	1·9988	1·9928
1·9992	1·9990	1·9875	2·0093	1·9810	2·0063	1·9971
2·0005	1·9965	1·9893	2·0105	1·9842	2·0098	1·9985

ELEVENTH SERIES. TABLE I.—*continued.*

104–105	105–106	106–107	107–108	108–109	109–110	Mean
2·0027	1·9962	1·9962	1·9995	1·9930	2·0055	1·9988
1·9997	1·9963	·9960	1·9918	1·9970	2·0043	1·9975
1·9987	1·9972	·9965	1·9903	2·0015	2·0082	1·9987

110–111	111–112	112–113	113–114	114–115	115–116	Mean
1·9852	1·9948	1·9920	1·9938	1·9963	1·9955	1·9929
1·9812	1·9972	1·9985	1·9888	1·9932	1·9997	1·9931
1·9822	1·9965	1·9865	1·9930	1·9948	1·9965	1·9916

116–117	117–118	118–119	119–120	120–121	121–122	Mean
1·9985	2·0013	2·0002	2·0103	1·9920	2·0025	2·0008
·9990	1·9997	1·9945	2·0032	1·9920	2·0035	1·9987
·9985	1·9998	1·9955	2·0002	2·0040	2·0047	2·0005

122–123	123–124	124–125	125–126	126–127	127–128	Mean
2·0070	1·9953	2·0045	1·9995	2·0025	1·9970	2·0010
1·9962	2·0033	2·0068	1·9970	1·9990	1·9985	2·0001
2·0060	2·0027	2·0023	2·0043	2·0025	1·9962	2·0023

128–129	129–130	130–131	131–132	·132–133	133–134	Mean
2·0100	2·0020	2·0085	1·9937	2·0100	1·9945	2·0031
2·0025	2·0030	2·0045	1·9942	2·0075	2·0013	2·0022
2·0060	1·9955	2·0063	1·9965	2·0088	1·9995	2·0021

134–135	135–136	136–137	137–138	138–139	139–140	Mean
1·9980	1·9945	2·0002	2·0002	2·0090	1·9897	1·9986
1·9977	2·0010	2·0000	2·0020	2·0025	1·9900	1·9989
2·0067	1·9915	1·9998	1·9995	2·0032	1·9935	1·9990

140–141	141–142	142–143	143–144	144–145	145–146	Mean
1·9967	1·9982	1·9950	1·9970	2·0043	1·9853	1·9961
2·0005	1·9975	2·0025	1·9953	2·0070	1·9860	1·9981
2·0047	1·9927	2·0002	1·9980	1·9995	1·9837	1·9965

ELEVENTH SERIES. TABLE I.—*continued.*

SCALE B.

2–3	3–4	4–5	5–6	6–7	7–8	Mean
1·9983	1·9977	1·9980	2·0022	1·9862	2·0010	1·9972
1·9985	1·9907	1·9970	1·9972	1·9900	1·9998	1·9955
1·9965	1·9948	1·9962	2·0092	1·9920	1·9987	1·9979

8–9	9–10	10–11	11–12	12–13	13–14	Mean
1·9968	1·9965	1·9928	2·0013	1·9943	1·9920	1·9956
1·9968	1·9942	1·9955	1·9953	1·9940	1·9930	1·9948
1·9880	1·9933	1·9940	1·9930	1·9932	1·9973	1·9931

14–15	15–16	16–17	17–18	18–19	19–20	Mean
2·0007	1·9980	2·0010	1·9973	1·9973	2·0048	1·9999
2·0052	2·0022	2·0085	1·9982	1·9925	2·0030	2·0016
1·9980	1·9995	2·0045	1·9992	2·0005	2·0070	2·0015

20–21	21–22	22–23	23–24	24–25	25–26	Mean
1·9998	1·9947	2·0025	1·9952	1·9933	2·0085	1·9990
2·0020	2·0017	1·9973	1·9962	2·0005	2·0045	2·0004
2·0070	1·9992	2·0068	1·9943	1·9980	2·0065	2·0020

26–27	27–28	28–29	29–30	30–31	31–32	Mean
1·9895	1·9985	1·9865	2·0070	1·9932	2·0022	1·9962
1·9900	1·9985	2·0000	2·0083	1·9993	2·0045	2·0001
1·9920	2·0015	1·9888	2·0055	1·9910	2·0028	1·9969

32–33	33–34	34–35	35–36	36–37	37–38	Mean
1·9880	1·9923	1·9990	1·9903	1·9930	1·9919	1·9924
1·9798	1·9972	1·9953	1·9860	1·9905	1·9930	1·9903
1·9870	1·9943	1·9915	1·9915	1·9950	1·9950	1·9924

38–39	39–40	40–41	41–42	42–43	43–44	Mean
1·9913	1·9955	1·9905	1·9893	1·9972	2·0008	1·9941
1·9912	1·9955	1·9898	1·9885	1·9962	1·9975	1·9931
1·9945	2·0030	1·9957	1·9935	1·9960	1·9978	1·9968

44–45	45–46	46–47	47–48	48–49	49–50	Mean
1·9950	1·9995	1·9885	1·9955	1·9965	1·9838	1·9931
1·9890	2·0028	1·9927	1·9973	2·0032	1·9907	1·9960
1·9885	2·0058	1·9945	1·9897	1·9967	1·9850	1·9934

ELEVENTH SERIES. TABLE I.—*continued.*

98–99	99–100	100–101	101–102	102–103	103–104	Mean
1·9848	2·0010	1·9858	1·9925	1·9928	1·9983	1·9925
1·9917	1·9968	1·9932	1·9895	1·9935	1·9968	1·9936
1·9963	1·9995	1·9995	1·9923	2·0008	1·9985	1·9978

104–105	105–106	106–107	107–108	108–109	109–110	Mean
1·9915	1·9985	1·9900	1·9977	1·9938	1·9915	1·9938
1·9968	2·0000	1·9867	2·0005	1·9983	1·9910	1·9956
1·9905	2·0015	1·9853	1·9963	2·0048	1·9877	1·9944

110–111	111–112	112–113	113–114	114–115	115–116	Mean
1·9912	1·9888	1·9938	1·9890	1·9890	1·9980	1·9916
1·9900	1·9935	1·9942	1·9837	1·9990	1·9960	1·9927
1·9898	1·9963	1·9948	1·9805	1·9943	2·0013	1·9928

116–117	117–118	118–119	119–120	120–121	121–122	Mean
1·9967	1·9960	1·9847	2·0002	2·0000	1·9825	1·9934
1·9973	1·9968	1·9888	1·9975	2·0057	1·9853	1·9952
1·9977	1·9913	1·9880	2·0067	1·9950	1·9995	1·9964

122–123	123–124	124–125	125–126	126–127	127–128	Mean
2·0055	1·9788	2·0062	1·9948	1·9897	2·0005	1·9959
2·0027	1·9755	1·9977	1·9950	1·9915	1·9993	1·9936
1·9972	1·9783	2·0107	1·9925	2·0008	1·9933	1·9955

128–129	129–130	130–131	131–132	132–133	133–134	Mean
1·9925	2·0020	1·9970	2·0077	2·0053	1·9962	2·0001
1·9908	1·9935	1·9970	2·0160	1·9940	1·9938	1·9975
1·9957	1·9968	1·9938	2·0118	1·9993	1·9970	1·9991

134–135	135–136	136–137	137–138	138–139	139–140	Mean
1·9915	2·0040	1·9943	1·9887	1·9932	1·9910	1·9938
2·0032	1·9935	1·9860	1·9870	1·9980	1·9947	1·9937
1·9903	1·9968	1·9885	1·9745	1·9968	1·9982	1·9909

140–141	141–142	142–143	143–144	144–145	145–146	Mean
2·0133	1·9875	2·0030	1·9905	2·0138	1·9960	2·0007
2·0015	1·9990	2·0018	1·9910	2·0075	1·9915	1·9987
2·0020	1·9988	2·0068	1·9890	2·0083	1·9985	2·0006

The Eleventh Series, Table II., gives the results deduced from each double web separately, and the mean which is adopted as the true error of the length of each single-division space in terms of the 6-division space to which it belongs.

ELEVENTH SERIES. TABLE II.

SCALE A.

2–8

2–3	3–4	4–5	5–6	6–7	7–8
– ·0022	– ·0027	+ ·0013	+ ·0020	– ·0015	+ ·0031
+ ·0013	+ ·0021	– ·0012	– ·0051	– ·0021	+ ·0049
+ ·0062	+ ·0003	– ·0061	+ ·0042	– ·0003	– ·0036
+ ·0018	– ·0003	– ·0020	+ ·0004	– ·0013	+ ·0015

8–14

8–9	9–10	10–11	11–12	12–13	13–14
– ·0086	+ ·0011	– ·0036	– ·0001	+ ·0056	+ ·0057
– ·0120	+ ·0058	+ ·0053	+ ·0001	+ ·0123	– ·0017
– ·0035	+ ·0017	– ·0038	+ ·0032	+ ·0099	– ·0073
– ·0080	+ ·0029	– ·0007	+ ·0011	+ ·0093	– ·0011

14–20

14–15	15–16	16–17	17–18	18–19	19–20
– ·0028	+ ·0036	+ ·0042	– ·0099	+ ·0001	+ ·0049
+ ·0011	– ·0029	+ ·0072	– ·0153	+ ·0031	+ ·0066
+ ·0021	– ·0023	+ ·0069	– ·0121	– ·0061	+ ·0112
+ ·0001	– ·0005	+ ·0061	– ·0124	– ·0010	+ ·0076

20–26

20–21	21–22	22–23	23–24	24–25	25–26
– ·0024	+ ·0047	+ ·0086	– ·0088	– ·0006	– ·0016
+ ·0065	+ ·0014	+ ·0092	– ·0121	– ·0005	– ·0048
+ ·0048	– ·0025	+ ·0058	– ·0017	– ·0070	+ ·0003
+ ·0030	+ ·0012	+ ·0079	– ·0075	– ·0027	– ·0020

ELEVENTH SERIES. TABLE II.—*continued.*

26–32

26–27	27–28	28–29	29–30	30–31	31–32
+ ·0037	− ·0041	− ·0011	− ·0004	+ ·0079	− ·0061
− ·0038	− ·0023	+ ·0025	+ ·0042	+ ·0099	− ·0108
+ ·0026	− ·0015	− ·0019	− ·0034	+ ·0111	− ·0069
+ ·0008	− ·0026	− ·0002	+ ·0001	+ ·0096	− ·0079

32–38

32–33	33–34	34–35	35–36	36–37	37–38
+ ·0027	+ ·0028	− ·0047	+ ·0015	− ·0048	+ ·0027
− ·0001	+ ·0046	+ ·0041	− ·0044	− ·0031	− ·0014
− ·0031	+ ·0014	+ ·0013	− ·0004	+ ·0036	− ·0029
− ·0002	+ ·0029	+ ·0002	− ·0011	− ·0014	− ·0005

38–44

38–39	39–40	40–41	41–42	42–43	43–44
− ·0048	+ ·0060	− ·0018	+ ·0048	− ·0040	− ·0005
+ ·0041	+ ·0096	− ·0094	− ·0032	− ·0012	− ·0002
+ ·0023	+ ·0116	− ·0049	− ·0056	+ ·0009	− ·0045
+ ·0005	+ ·0091	− ·0054	− ·0013	− ·0014	− ·0017

44–50

44–45	45–46	46–47	47–48	48–49	49–50
+ ·0016	− ·0017	− ·0017	− ·0082	+ ·0025	+ ·0076
+ ·0102	− ·0043	− ·0048	− ·0055	− ·0038	+ ·0080
+ ·0020	− ·0017	− ·0003	+ ·0027	− ·0053	+ ·0028
+ ·0046	− ·0026	− ·0023	− ·0037	− ·0022	+ ·0061

98–104

98–99	99–100	100–101	101–102	102–103	103–104
+ ·0042	+ ·0022	− ·0055	+ ·0067	− ·0135	+ ·0060
+ ·0021	+ ·0019	− ·0096	+ ·0122	− ·0161	+ ·0092
+ ·0020	− ·0020	− ·0092	+ ·0120	− ·0143	+ ·0113
+ ·0028	+ ·0007	− ·0081	+ ·0103	− ·0146	+ ·0088

104–110

104–105	105–106	106–107	107–108	108–109	109–110
+ ·0037	− ·0026	− ·0026	+ ·0007	− ·0058	+ ·0067
+ ·0022	− ·0012	− ·0015	− ·0057	− ·0005	+ ·0068
− ·0000	− ·0015	− ·0022	− ·0084	+ ·0028	+ ·0095
+ ·0020	− ·0018	− ·0021	− ·0045	− ·0012	+ ·0077

ELEVENTH SERIES. TABLE II.—*continued.*

110–116

110–111	111–112	112–113	113–114	114–115	115–116
−·0077	+·0019	−·0009	+·0009	+·0034	+·0026
−·0119	+·0041	+·0054	−·0043	+·0001	+·0066
−·0094	+·0049	−·0051	+·0014	+·0032	+·0049
−·0097	+·0036	−·0002	−·0007	+·0022	+·0047

116–122

116–117	117–118	118–119	119–120	120–121	121–122
−·0023	+·0005	−·0006	+·0095	−·0088	+·0017
+·0003	+·0010	−·0042	+·0045	−·0067	+·0048
−·0020	−·0007	−·0050	−·0003	+·0035	+·0042
−·0013	+·0003	−·0033	+·0046	−·0040	+·0036

122–128

122–123	123–124	124–125	125–126	126–127	127–128
+·0060	−·0057	+·0035	−·0015	+·0015	−·0040
−·0039	+·0032	+·0067	−·0031	−·0011	−·0016
+·0037	+·0004	±·0000	+·0020	+·0002	−·0061
+·0019	−·0007	+·0034	−·0009	+·0002	−·0039

128–134

128–129	129–130	130–131	131–132	132–133	133–134
+·0069	−·0011	+·0054	−·0094	+·0069	−·0086
+·0003	+·0008	+·0023	−·0080	+·0053	−·0009
+·0039	−·0066	+·0042	−·0056	+·0067	−·0026
+·0037	−·0023	+·0040	−·0077	+·0063	−·0040

134–140

134–135	135–136	136–137	137–138	138–139	139–140
−·0006	−·0041	+·0016	+·0016	+·0104	−·0089
−·0012	+·0021	+·0011	+·0031	+·0036	−·0089
+·0077	−·0075	+·0008	+·0005	+·0042	−·0055
+·0020	−·0032	+·0012	+·0017	+·0061	−·0078

140–146

140–141	141–142	142–143	143–144	144–145	145–146
+·0006	+·0021	−·0011	+·0009	+·0082	−·0108
+·0024	−·0006	+·0044	+·0028	+·0089	−·0121
+·0082	−·0038	+·0037	+·0015	+·0030	−·0128
+·0037	−·0008	+·0023	−·0001	+·0067	−·0119

ELEVENTH SERIES. TABLE II.—*continued.*

SCALE B.

2–8					
2–3	3–4	4–5	5–6	6–7	7–8
+ ·0011	+ ·0005	+ ·0008	+ ·0050	− ·0110	+ ·0038
+ ·0030	− ·0048	+ ·0015	+ ·0017	− ·0055	+ ·0043
− ·0014	− ·0031	− ·0017	+ ·0113	− ·0059	+ ·0008
+ ·0007	− ·0025	+ ·0002	+ ·0060	− ·0075	+ ·0030

8–14					
8–9	9–10	10–11	11–12	12–13	13–14
+ ·0012	+ ·0009	− ·0028	+ ·0057	− ·0013	− ·0036
+ ·0020	− ·0006	+ ·0007	+ ·0005	− ·0008	− ·0018
− ·0049	+ ·0002	+ ·0009	− ·0001	+ ·0001	+ ·0042
− ·0006	+ ·0002	− ·0004	+ ·0020	− ·0007	− ·0004

14–20					
14–15	15–16	16–17	17–18	18–19	19–20
+ ·0008	− ·0019	+ ·0011	− ·0026	− ·0026	+ ·0049
+ ·0036	+ ·0006	+ ·0069	− ·0034	− ·0091	+ ·0014
− ·0035	− ·0020	+ ·0030	− ·0023	− ·0010	+ ·0055
+ ·0003	− ·0011	+ ·0037	− ·0028	− ·0042	+ ·0039

20–26					
20–21	21–22	22–23	23–24	24–25	25–26
+ ·0008	− ·0043	+ ·0035	− ·0038	− ·0057	+ ·0095
+ ·0016	+ ·0013	− ·0031	− ·0042	+ ·0001	+ ·0041
+ ·0050	− ·0028	+ ·0048	− ·0077	− ·0040	+ ·0045
+ ·0025	− ·0019	+ ·0017	− ·0052	− ·0032	+ ·0060

26–32					
26–27	27–28	28–29	29–30	30–31	31–32
− ·0067	+ ·0023	− ·0097	+ ·0108	− ·0030	+ ·0060
− ·0101	− ·0016	− ·0001	+ ·0082	− ·0008	+ ·0044
− ·0049	+ ·0046	− ·0081	+ ·0086	− ·0059	+ ·0059
− ·0072	+ ·0018	− ·0060	+ ·0092	− ·0032	+ ·0054

ELEVENTH SERIES. TABLE II.—*continued.*

32–38					
32–33	33–34	34–35	35–36	36–37	37–38
– ·0044	– ·0001	+ ·0066	– ·0021	+ ·0006	– ·0005
– ·0105	+ ·0069	+ ·0050	– ·0043	+ ·0002	+ ·0027
– ·0054	+ ·0019	– ·0007	– ·0007	+ ·0026	+ ·0026
– ·0068	+ ·0029	+ ·0036	– ·0024	+ ·0011	+ ·0016

38–44					
38–39	39–40	40–41	41–42	42–43	43–44
– ·0028	+ ·0014	– ·0036	– ·0048	+ ·0031	+ ·0067
– ·0019	+ ·0024	– ·0033	– ·0046	+ ·0031	+ ·0044
– ·0023	+ ·0062	– ·0011	– ·0033	– ·0008	+ ·0010
– ·0023	+ ·0033	– ·0027	– ·0042	+ ·0018	+ ·0040

44–50					
44–45	45–46	46–47	47–48	48–49	49–50
+ ·0019	+ ·0064	– ·0046	+ ·0024	+ ·0034	– ·0093
– ·0070	+ ·0068	– ·0033	+ ·0013	+ ·0072	– ·0053
– ·0049	+ ·0124	+ ·0011	– ·0037	+ ·0033	– ·0084
– ·0033	+ ·0085	– ·0023	± ·0000	+ ·0046	– ·0077

98–104					
98–99	99–100	100–101	101–102	102–103	103–104
– ·0077	+ ·0085	– ·0067	– ·0000	+ ·0003	+ ·0058
– ·0019	+ ·0032	– ·0004	– ·0041	– ·0001	+ ·0032
– ·0015	+ ·0017	+ ·0017	– ·0055	+ ·0030	+ ·0007
– ·0037	+ ·0045	– ·0018	– ·0032	+ ·0011	+ ·0032

104–110					
104–105	105–106	106–107	107–108	108–109	109–110
– ·0023	+ ·0047	– ·0038	+ ·0039	+ ·0000	– ·0023
+ ·0012	+ ·0044	– ·0089	+ ·0049	+ ·0027	– ·0046
– ·0039	+ ·0071	– ·0091	+ ·0019	+ ·0104	– ·0067
– ·0017	+ ·0054	– ·0073	+ ·0036	+ ·0044	– ·0045

110–116					
110–111	111–112	112–113	113–114	114–115	115–116
– ·0004	– ·0028	+ ·0022	– ·0026	– ·0026	+ ·0064
– ·0027	+ ·0008	+ ·0015	– ·0090	+ ·0063	+ ·0033
– ·0030	+ ·0035	+ ·0020	– ·0123	+ ·0015	+ ·0085
– ·0020	+ ·0005	+ ·0019	– ·0080	+ ·0017	+ ·0061

ELEVENTH SERIES. TABLE II.—*continued.*

116–122

116–117	117–118	118–119	119–120	120–121	121–122
+ ·0033	+ ·0026	− ·0087	+ ·0068	+ ·0066	− ·0109
+ ·0021	+ ·0016	− ·0064	+ ·0023	+ ·0105	− ·0099
+ ·0013	− ·0051	− ·0084	+ ·0103	− ·0014	+ ·0031
+ ·0022	− ·0003	− ·0078	+ ·0065	+ ·0052	− ·0059

122–128

122–123	123–124	124–125	125–126	126–127	127–128
+ ·0096	− ·0171	+ ·0103	− ·0011	− ·0062	+ ·0046
+ ·0091	− ·0181	+ ·0041	+ ·0014	− ·0021	+ ·0057
+ ·0017	− ·0172	+ ·0152	− ·0030	+ ·0053	− ·0022
+ ·0068	− ·0175	+ ·0099	− ·0009	− ·0010	+ ·0027

128–134

128–129	129–130	130–131	131–132	132–133	133–134
− ·0076	+ ·0019	− ·0031	+ ·0076	+ ·0052	− ·0039
− ·0067	− ·0040	− ·0005	+ ·0185	− ·0035	− ·0037
− ·0034	− ·0023	− ·0053	+ ·0127	+ ·0002	− ·0021
− ·0059	− ·0015	− ·0030	+ ·0129	+ ·0006	− ·0032

134–140

134–135	135–136	136–137	137–138	138–139	139–140
− ·0023	+ ·0102	+ ·0005	− ·0051	− ·0006	− ·0028
+ ·0095	− ·0002	− ·0077	− ·0067	+ ·0043	+ ·0010
− ·0006	+ ·0059	− ·0024	− ·0164	+ ·0059	+ ·0073
+ ·0022	+ ·0053	− ·0032	− ·0094	+ ·0032	+ ·0018

140–146

140–141	141–142	142–143	143–144	144–145	145–146
+ ·0126	− ·0132	+ ·0023	− ·0102	+ ·0131	− ·0047
+ ·0028	+ ·0003	+ ·0031	− ·0077	+ ·0088	− ·0072
+ ·0014	− ·0018	+ ·0062	− ·0116	+ ·0077	− ·0021
+ ·0056	− ·0049	+ ·0039	− ·0098	+ ·0099	− ·0047

The material now at disposal for deducing the definitive corrections to be applied to the various divisions is as follows :—

	Fundamental Scale					Beyond Fund. Scale	
	Total number of bisections	Number of independent measures of each space of 12 divisions	Number of independent measures of each space of 6 divisions	Number of independent measures of each space of 3 divisions	Number of independent measures of each single-division space	Number of independent measures of each 6-division space	Number of independent measures of each single-division space
First Series .	768	48	...	...	...	...	...
Second „ .	832	56	...	...	...	...	...
Third „ .	512	...	16	...	...	...	...
Fourth „ .	512	...	16	...	...	...	...
Fifth „ .	512	16	16	...	...	...	...
Sixth „ .	1024	64	...	...	...	...	...
Seventh „ .	1024	64	64	...	...	...	...
Eighth „ .	1536	...	...	12	...	...	...
Ninth „ .	1536	..	...	...	8	...	...
Tenth „ .	4096	64	64	...	...	32	...
Eleventh „ .	4608	...	...	...	...	...	12
Total . .	16,960	312	176	12	8	32	12

These series have been combined as follows. The weights have been assigned partly according to the number of observations, but chiefly from the probability of freedom from systematic error of the series by the arrangement of the observations.

Combination of Series for Definitive Errors of Length of a, β, γ, etc.

	Weight	Scale A				Scale B			
		a	β	γ	δ	a'	β'	γ'	δ'
First Series . .	12	+ ·0107	− ·0078	+ ·0031	− ·0059	+ ·0046	+ ·0033	− ·0037	− ·0041
Second „ . .	13	+ ·0082	− ·0065	+ ·0022	− ·0039	+ ·0021	+ ·0020	− ·0025	− ·0016
Fifth „ . .	3	+ ·0027	− ·0022	+ ·0022	− ·0026	+ ·0038	+ ·0002	− ·0040	− ·0000
Sixth „ . .	24	+ ·0080	− ·0079	+ ·0046	− ·0047	+ ·0046	+ ·0017	− ·0045	− ·0019
Seventh „ . .	9	+ ·0035	− ·0066	+ ·0031	+ ·0001	+ ·0010	+ ·0011	− ·0015	− ·0006
Tenth „ . .	18	+ ·0146	− ·0081	− ·0015	− ·0050	+ ·0041	+ ·0003	− ·0025	− ·0018
Resulting mean . . .		+ ·0092	− ·0073	+ ·0023	− ·0042	+ ·0036	+ ·0015	− ·0032	− ·0019
Probable error . . .		± ·0010	± ·0003	± ·0006	± ·0004	± ·0004	± ·0003	± ·0003	± ·0002
Do. in arc		± 0″·026	± 0″·008	± 0″·015	± 0″·010	± 0″·010	± 0″·008	± 0″·008	± 0″·005

The probable error of the final determination of the division error of one of the spaces a, β, γ, &c., is from these results = ± ·0005 revolutions = ± 0″·013.

COMBINATION OF SERIES FOR ERRORS OF THE LENGTH OF THE 6-DIVISION SPACES IN TERMS OF THE FUNDAMENTAL 12-DIVISION SPACES TO WHICH THEY BELONG.

SCALE A

	Weight	α		β		γ		δ	
		50–56	56–62	62–68	68–74	74–80	80–86	86–92	92–98
Third Series . .	2	+ ·0050	− ·0050	+ ·0083	− ·0083	+ ·0042	− ·0042	− ·0031	+ ·0031
Fourth „ . .	2	+ ·0066	− ·0066	+ ·0069	− ·0069	+ ·0035	− ·0035	− ·0017	+ ·0017
Fifth „ . .	2	+ ·0053	− ·0053	+ ·0091	− ·0091	+ ·0041	− ·0041	− ·0001	+ ·0001
Seventh „ . .	4	+ ·0049	− ·0049	+ ·0029	− ·0029	+ ·0048	− ·0048	− ·0051	+ ·0051
Tenth „ . .	8	+ ·0022	− ·0022	+ ·0072	− ·0072	+ ·0040	− ·0040	+ ·0021	− ·0021
Resulting mean . . .		+ ·0039	− ·0039	+ ·0065	− ·0065	+ ·0042	− ·0042	− ·0007	+ ·0007
Probable error . . .		± ·0007	...	± ·0007	...	± ·0002	...	± ·0012	...
Do. in arc		± 0″·018	...	± 0″·018	...	± 0″·005	...	± 0″·030	...

SCALE B

	Weight	α'		β'		γ'		δ'	
		50–56	56–62	62–68	68–74	74–80	80–86	86–92	92–98
Third Series . .	2	+ ·0050	− ·0050	+ ·0022	− ·0022	− ·0005	+ ·0005	+ ·0036	− ·0036
Fourth „ . .	2	+ ·0009	− ·0009	+ ·0056	− ·0056	+ ·0027	− ·0027	+ ·0032	− ·0032
Fifth „ . .	2	+ ·0029	− ·0029	+ ·0025	− ·0025	+ ·0060	− ·0060	+ ·0041	− ·0041
Seventh „ . .	4	+ ·0024	− ·0024	+ ·0009	− ·0009	+ ·0057	− ·0057	+ ·0024	− ·0024
Tenth „ . .	8	− ·0004	+ ·0004	+ ·0027	− ·0027	+ ·0060	− ·0060	− ·0029	+ ·0029
Resulting mean . . .		+ ·0013	− ·0013	+ ·0025	− ·0025	+ ·0048	− ·0048	+ ·0005	− ·0005
Probable error . . .		± ·0007	...	± ·0004	...	± ·0007	...	± ·0013	...
Do. in arc		± 0″·018	...	± 0″·010	...	± 0″·018	...	± 0″·033	...

The probable error of the determination of error of the bisection of the spaces α, β, γ, &c., is from these results ± ·0009 revolutions = ± 0″·023.

The Tenth Series is the only one available for determining the lengths of 6-division spaces beyond the fundamental scale; the values of the lengths of the 6-division spaces below 50 and above 98 are therefore taken as definitive from the *means* in the Tenth Series, Table I.

To compute the probable error from the Tenth Series, Table I., it would be necessary to substitute values of the length of α, β, γ, &c., which values would also be affected with a certain probable error.

It is easier to compute from the Tenth Series, Table II., which gives the probable error of the determination of the 6-division-space errors of the fundamental scale as determined independently by each 6-division space above and below the fundamental scale, and the accuracy of these determinations must exactly represent the accuracy of the determinations of the comparative length of the 6-division spaces whose probable errors we require, excepting that the

spaces in Table II. are compared sixteen times instead of eight times only, as in Table I.; and therefore, to find the probable error of the 6-division spaces in Table I., the probable error deduced from Tenth Series, Table II., must be multiplied by $\sqrt{2}$.

The sum of the squares of the probable errors in Tenth Series, Table II., = ·0000145640.

$$\text{Hence } v = \sqrt{\frac{\cdot 0000145640}{16}} = \pm 0^{r}\cdot 00098.$$

and the

probable error of results in Tenth Series, Table II., $= \pm \cdot 00098 \times \sqrt{2} = \pm 0^{r}\cdot 00138 = \pm 0''\cdot 035$.

The results of the Eighth Series are taken as definitive for subdividing the 6-division spaces of the fundamental scale into two parts of three divisions each.

The probable error of this bisection is $\pm 0''\cdot 013$.

In the fundamental scale the subdivision to single divisions is arrived at solely by the Ninth Series, which trisects the 3-division spaces of the Eighth Series. There is no direct means of arriving at the probable error of the determination of the results of this series.

From the agreement of the measures *inter se* the probable error of a single measure of the distance between two adjacent divisions was found to be $\pm 0^{r}\cdot 003$; and since we cannot suppose the run to have changed sensibly during the comparison of three divisions, we may safely take the probable error of the determination of the length of one division

$$= \frac{\pm 0^{r}\cdot 003}{\sqrt{\text{No. of obs.}}} = \frac{\pm 0^{r}\cdot 003}{\sqrt{8}} = \pm 0^{r}\cdot 00106 = \pm 0''\cdot 027.$$

In the divisions beyond the fundamental scale no determination of 3-division spaces was made, and the determination of the length of the single-division spaces depends upon Second Series, by which the 6-division spaces are subdivided into six spaces of one division each.

The results of this series, as given in Eleventh Series, Table II., are accepted as definitive.

Here also there is no direct means of arriving at the probable error of the result, because, though there are three independent measures shown, they are made with different parts of the screw. No error is involved in the mean, but to estimate the probable error we must adopt the last method and put it

$$= \frac{\pm 0^{r}\cdot 003}{\sqrt{\text{No. of obs.}}} = \frac{\pm 0^{r}\cdot 003}{\sqrt{12}} = \pm 0^{r}\cdot 000866 = \pm 0''\cdot 022.$$

The actual excesses of the lengths of every 12-division space, 6-division space, 3-division space, and single-division space on the fundamental scale, and of each 6-division space and single-division space in the extreme parts of the scale, having been determined relative to the

normal values of these in the fundamental scale, we can now proceed to complete the table for correcting these errors of division.

Beginning with division 2, Scale *A*, we find the excess of the space 2–8 (Tenth Series, Table I.) = + ·0158. From the same table we find the excess of the space 8–14 = + ·0070, whence the excess of 2–14 = + ·0158 + ·0070 = + ·0228, and so on by successive addition till we arrive at 50, when the total excess becomes ·0475.

Now, the 12-division spaces have been determined, and from the definitive tables for length of α, β, γ, &c., we find the definitive excess of 50–62 (α) = + ·0092, which added to the excess of 50 makes the total excess = ·0567 for division 62; similarly the excess for 62–74 (β) = − ·0073, whence the excess of 74 = ·0494, and so on till we reach 98, when the excess again becomes ·0475, the same as for division 50, as it necessarily must, because 50–98 is the normal scale.

From 98 to 146 the addition is now continued to the end of the scale by sixes from the excesses of Tenth Series, Table I.[1]

The next step is to fill in the 6-division spaces of the fundamental scale.

If the division 56 was exactly halfway between 50 and 62, its division error would be the mean of the division errors of 50 and 62 = $\frac{·0475 + ·0567}{2}$.

But by the final discussion of the bisection of the 12-division spaces we find from the table that 50–56 is longer than the half of 50–62 by +0″·0039; therefore the excess for 56 = $\frac{·0475 + ·0569}{2}$ + ·0039 = ·0560.

The errors of the other 6-division spaces are computed in the same way, and precisely in a similar manner the division errors of the 3-division spaces are interpolated.

To deduce the errors of the single-division spaces, take for example 50–53, Scale *A*.

The error of 52 is ·0544; that of 50, ·0475: the space 50–53 is therefore too great by ·0544 − ·0475 = + ·0069.

If each of the single divisions was exactly one-third of the interval 50–53, we should obtain the true error of 51 by adding + $\frac{·0069}{3}$ = + ·0023 to the error of 50, the error of 52 by adding + ·0023 to the previous error, and so on; but we find by Ninth Series that

for	50–51	51–52	52–53
the errors are	− ·0003	·0024	+ ·0027
to which we must add	+ ·0023	+ ·0023	+ ·0023
	+ ·0020	− ·0001	+ ·0050
Error of (50)	·0475		
Error of (51)	·0495	·0495	
Error of (52)	—	·0494	·0494
Error of (53)	—	—	·0549

agreeing of course with error already found.

Thus all the errors of the single divisions of the fundamental scale are interpolated.

[1] The extreme parts of the scale happen to be longer than the central (the fundamental) part; had this not been so it would have been convenient to begin with an imaginary quantity for 2, to prevent the occurrence of negative quantities.

In a precisely similar manner the errors of the single divisions of the scale beyond the fundamental scale are interpolated, only excepting that the error of the 6-division space is divided by six, and the successive addition carried on for six divisions.

The accompanying table shows the result of the operation for both scales, and gives for each division the *error* of its distance from division 2.

This *error* is really the required *correction*, for if a portion of a scale is too long its *apparent* angular value is too small, and the required *correction* is the error of its length. The errors of the distance from division 2, thus found, are therefore the *corrections* to be applied to each reading to convert all measures into true portions of the normal scale.[1]

[1] This very simple bit of reasoning was not employed at first, and so it happened that the whole of the observations recorded in this volume were originally reduced with the *reversed signs* of the division errors.

The result in the case of the Juno observations is afterwards given in some detail.

TABLE OF CORRECTIONS FOR DIVISION ERROR OF HELIOMETER. SCALE A.

No. of division	Sum of successive excesses of length of 12-division spaces	Sum of successive excesses of length of 6-division spaces	Interpolated single-division spaces	No. of division	Sum of successive excesses of length of 12-division spaces	Interpolated bisections of 12-division spaces	Interpolated bisections of 6-division spaces	Interpolated single-division lengths	No. of division	Sum of successive excesses of length of 12-division spaces	Sum of successive excesses of length of 6-division spaces	Interpolated single-division spaces
2	·0000	·0000	...	50	·0475	...	...	...	98	·0475	·0475	...
3	...	...	·0044	51	...	...	...	·0495	99	...	...	·0505
4	...	...	·0068	52	...	...	...	·0494	100	...	...	·0515
5	...	...	·0074	53	...	...	·0544	...	101	...	...	·0436
6	...	...	·0104	54	...	...	...	·0513	102	...	...	·0541
7	...	...	·0117	55	...	...	...	·0561	103	...	...	·0397
8	...	·0158	...	56	...	·0560	...	...	104	...	·0489	...
9	...	...	·0084	57	...	...	...	·0537	105	...	...	·0508
10	...	...	·0118	58	...	...	...	·0594	106	...	...	·0489
11	...	...	·0117	59	...	...	·0534	...	107	...	...	·0467
12	...	...	·0134	60	...	...	...	·0627	108	...	...	·0421
13	...	...	·0232	61	...	...	...	·0534	109	...	...	·0408
14	...	·0228	...	62	·0567	...	...	...	110	...	·0483	...
15	...	...	·0250	63	...	...	...	·0551	111	...	...	·0385
16	...	...	·0264	64	...	...	...	·0516	112	...	...	·0419
17	...	...	·0346	65	...	...	·0564	...	113	...	...	·0414
18	...	...	·0242	66	...	...	...	·0551	114	...	...	·0406
19	...	...	·0253	67	...	...	...	·0568	115	...	...	·0427
20	...	·0351	...	68	...	·0596	...	...	116	...	·0474	...
21	...	...	·0389	69	...	...	...	·0637	117	...	...	·0465
22	...	...	·0408	70	...	...	...	·0646	118	...	...	·0472
23	...	...	·0495	71	...	...	·0597	...	119	...	...	·0478
24	...	...	·0427	72	...	...	...	·0546	120	...	...	·0528
25	...	...	·0409	73	...	...	...	·0494	121	...	...	·0492
26	...	·0396	...	74	·0494	...	...	...	122	...	·0535	...
27	...	...	·0405	75	...	...	...	·0498	123	...	...	·0581
28	...	...	·0380	76	...	...	...	·0478	124	...	...	·0601
29	...	...	·0379	77	...	...	·0538	...	125	...	...	·0662
30	...	...	·0381	78	...	...	...	·0519	126	...	...	·0680
31	...	...	·0478	79	...	...	..	·0544	127	...	...	·0709
32	...	·0402	...	80	...	·0548	...	...	128	...	·0697	...
33	...	...	·0400	81	...	...	...	·0552	129	...	...	·0759
34	...	...	·0429	82	...	...	...	·0521	130	...	...	·0759
35	...	...	·0431	83	...	...	·0533	...	131	...	...	·0824
36	...	...	·0420	84	...	...	...	·0540	132	...	...	·0771
37	...	...	·0406	85	...	...	...	·0525	133	...	...	·0858
38	...	·0403	...	86	·0517	...	...	...	134	...	·0842	...
39	.	...	·0406	87	...	...	...	·0496	135	...	...	·0881
40	...	...	·0493	88	...	...	...	·0445	136	...	...	·0869
41	...	...	·0437	89	...	...	·0460	...	137	...	...	·0899
42	...	...	·0421	90	...	...	...	·0443	138	...	...	·0936
43	...	...	·0403	91	...	...	...	·0526	139	...	...	·1000
44	...	·0383	...	92	...	·0489	...	...	140	...	·0949	...
45	...	...	·0439	93	...	...	...	·0459	141	...	...	·0978
46	...	...	·0424	94	...	...	...	·0452	142	...	...	·0962
47	...	...	·0411	95	...	...	·0461	...	143	...	...	·0977
48	...	...	·0417	96	...	...	...	·0456	144	...	...	·0968
49	...	...	·0406	97	...	...	...	·0472	145	...	...	·1027
50	·0475	·0475	...	98	·0475	...	...	...	146	...	·0901	...

TABLE OF CORRECTIONS FOR DIVISION ERROR OF HELIOMETER. SCALE B.

No. of division	Sum of successive excesses of length of 12-division spaces	Sum of successive excesses of length of 6-division spaces	Interpolated single-division spaces	No. of division	Sum of successive excesses of length of 12-division spaces	Interpolated bi-sections of 12-division spaces	Interpolated bi-sections of 6-division spaces	Interpolated single-division lengths	No. of division	Sum of successive excesses of length of 12-division spaces	Sum of successive excesses of length of 6-division spaces	Interpolated single-division spaces
2	...	·0000	...	50	·0241	...	...	...	98	·0241	...	...
3	...	...	·0020	51	...	...	...	·0254	99	...	...	·0206
4	...	...	·0005	52	...	...	...	·0214	100	...	...	·0254
5	...	...	·0018	53	...	...	·0241	...	101	...	...	·0238
6	...	...	·0090	54	...	...	...	·0243	102	...	...	·0209
7	...	...	·0026	55	...	...	...	·0245	103	...	...	·0223
8	...	·0069	...	56	...	·0272	...	...	104	...	·0260	...
9	...	...	·0073	57	...	...	...	·0282	105	...	...	·0250
10	...	...	·0084	58	...	...	...	·0190	106	...	...	·0311
11	...	...	·0090	59	...	...	·0297	...	107	...	...	·0244
12	...	...	·0119	60	...	...	...	·0313	108	...	...	·0287
13	...	...	·0122	61	...	...	...	·0235	109	...	...	·0338
14	...	·0126	...	62	·0277	...	...	...	110	...	·0301	...
15	...	...	·0152	63	...	...	...	·0313	111	...	...	·0283
16	...	...	·0165	64	...	...	...	·0266	112	...	...	·0290
17	...	...	·0226	65	...	...	·0284	...	113	...	...	·0311
18	...	...	·0221	66	...	...	...	·0301	114	...	...	·0234
19	...	...	·0203	67	...	...	...	·0240	115	...	...	·0253
20	...	·0267	...	68	...	·0310	...	...	116	...	·0313	...
21	...	...	·0292	69	...	...	...	·0320	117	...	...	·0344
22	...	...	·0273	70	...	...	...	·0261	118	...	...	·0349
23	...	...	·0291	71	...	...	·0257	...	119	...	...	·0280
24	...	...	·0239	72	...	...	...	·0287	120	...	...	·0353
25	...	...	·0203	73	...	...	...	·0251	121	...	...	·0414
26	...	·0267	...	74	·0292	...	...	...	122	...	·0364	...
27	...	...	·0207	75	...	...	...	·0259	123	...	...	·0439
28	...	...	·0237	76	...	...	...	·0287	124	...	...	·0271
29	...	...	·0190	77	...	...	·0257	...	125	...	...	·0378
30	...	...	·0294	78	...	...	...	·0236	126	...	...	·0376
31	...	...	·0277	79	...	...	...	·0323	127	...	...	·0373
32	...	·0346	...	80	...	·0324	...	...	128	...	·0407	...
33	...	...	·0260	81	...	...	...	·0354	129	...	...	·0348
34	...	...	·0270	82	...	...	...	·0347	130	...	...	·0333
35	...	...	·0287	83	...	...	·0311	...	131	...	...	·0303
36	...	...	·0244	84	...	...	...	·0246	132	...	...	·0432
37	...	...	·0236	85	...	...	...	·0307	133	...	...	·0438
38	..	·0230	...	86	·0260	...	...	...	134	...	·0391	...
39	...	...	·0214	87	...	...	...	·0304	135	...	...	·0431
40	...	...	·0255	88	...	...	...	·0295	136	...	...	·0303
41	...	...	·0235	89	...	...	·0243	...	137	...	...	[illegible]
42	...	...	·0201	90	...	...	...	·0338	138	...	...	[illegible]
43	...	...	·0226	91	...	...	...	·0322	139	...	...	[illegible]
44	...	·0274	...	92	...	...	·0256	...	140	...	·0501	...
45	...	...	·0236	93	...	...	...	·0289	141	...	...	[illegible]
46	...	...	·0315	94	...	...	...	·0244	142	...	...	[illegible]
47	...	...	·0287	95	...	...	·0274	...	143	...	...	[illegible]
48	...	...	·0281	96	...	...	...	·0238	144	...	...	[illegible]
49	...	...	·8322	97	...	...	...	·0322	145	...	...	[illegible]
50	...	·0241	...	98	·0241	...	...	...	146	...	·0537	...

The original plan was to compare the 12-division spaces beyond the fundamental scale with each of the four fundamental 12-division spaces.

Also to insert webs at spaces of eight divisions apart, and compare the 8-division spaces beyond the fundamental scale with each of the six 8-division spaces of the fundamental scale, thus determining, precisely as in Tenth Series, not only the comparative lengths of the six 8-division spaces in the extreme parts of the scale.

These 8-division spaces should be again subdivided into spaces of four divisions, two divisions, and one division each.

The combined results of all these processes would undoubtedly have afforded a thoroughly satisfactory table of corrections for division error of the whole scale, but accidents occurred to prevent the completion of this design, and it remains to discuss the probable errors of the investigation as it now stands.

FUNDAMENTAL SCALE (50–98).

12-division spaces,	probable error of	determination of length	.	±0″·013
6-division spaces	„	„	bisection of 12-division space	±0·023
3-division spaces	„	„	„ „ 6-division space	±0·013
1-division spaces	„	„	trisection of 3-division space	±0·027

EXTREMITIES OF SCALE.

6-division spaces,	probable error of	comparison with one-eighth fundamental scale		±0″·035
1-division space	„	„	subdivision of 6-division space . . .	±0·022

Though for convenience the scale corrections have been constructed by adding the successive lengths from one end, it is obvious that the effects of division errors must be reckoned from the reading when the optical centres are in coincidence, which is nearly for each scale 74.

For convenience put

r_1 r_n = probable error of a division-error determination r_n for a division n;

$\beta_{n_1-n_2}$ = „ „ bisection of the space n_1-n_2;

r_0 = „ „ the determination of the error of the middle division between r_1 and n_2.

Then beginning with the fundamental scale, the probable error of the divisions 74+12 and 74−12 would be simply the probable error of the length of a 12-division space = ±0″·013, and these probable errors are accordingly to be entered in the spaces opposite these divisions in the table.

The probable error of the divisions 74 + 12 + 12 and 74 − 12 − 12 must be ±0″·013 × $\sqrt{2}$ = ±0″·018, and the probable error is entered in the same table opposite divisions 50 and 95.

The probable error of the determination of the error of division of the middle division between the two divisions n_1 and n_2, if the bisection of the space n_1-n_2 were performed without error, would be

$$r=\sqrt{\frac{r^2_{n_1}+r^2_{n_2}}{2}}.$$

But if this bisection is performed with the probable error = β, then

$$r_0=\sqrt{r^2 \quad \beta^2};$$

and this is the general expression for the probable error of the division-error determinations for 56, 68, 80, and 92, where $\beta = \pm 0''{\cdot}023$, and the resulting probable errors are respectively $\pm 0''{\cdot}028$, $\pm 0''{\cdot}025$, $\pm 0''{\cdot}025$, $\pm 0''{\cdot}028$.

The same general expression applies to the probable errors of the bisections of the 6-division spaces, but $\beta = \pm 0''{\cdot}013$.

Hence for the probable errors of the division-error determinations for divisions—

53	59	65	71	77	83	89	95
$r = \pm 0''{\cdot}027$	$\pm 0''{\cdot}025$	$\pm 0''{\cdot}024$	$\pm 0''{\cdot}022$	$\pm 0''{\cdot}022$	$\pm 0''{\cdot}024$	$\pm 0''{\cdot}025$	$\pm 0''{\cdot}027$

The length of each 3-division space is determined with a probable error of $\pm 0''{\cdot}013$, and the third of that space with a probable error $= \pm 0''{\cdot}004$.

The trisection is affected with a probable error of $\pm 0''{\cdot}027$ for each division; hence we can determine the probable error of each division by

$$\sqrt{r_n^2 + (\cdot 004)^2 + (\cdot 027)^2},$$

in which r_n is the probable error of the division whose r is known, and next adjacent to the division whose r is required.

To compute the probable error of the division-error determination beyond the fundamental scale, we have the length of each 6-division space determined with a probable error $= \pm 0''{\cdot}035$.

The divisions 50–6 (44) and 98+6 (104) will therefore have $r = \sqrt{(\cdot 018)^2 + (\cdot 035)^2} = \pm 0''{\cdot}039$;

„ (38) and (110) „ „ $= \sqrt{(\cdot 018)^2 + 2(\cdot 035)^2} = \pm 0''{\cdot}053$;

„ (32) and (116) „ „ $= \sqrt{(\cdot 018)^2 + 3(\cdot 035)^2} = \pm 0''{\cdot}064$;

and so on. Thus we obtain for

104	110	116	122	128	134	140	146
44	38	32	26	20	14	8	2
$\pm 0''{\cdot}039$	$\pm 0''{\cdot}053$	$\pm 0''{\cdot}064$	$\pm 0''{\cdot}072$	$\pm 0''{\cdot}080$	$\pm 0''{\cdot}087$	$\pm 0''{\cdot}094$	$\pm 0''{\cdot}101$

To find r_0 for the middle division between these we may proceed nearly as last.

If the 6-division space were perfectly bisected, the probable error of the middle space would

$$\text{be } r = \sqrt{r_{n_1}^2 + r_{n_2}^2}.$$

But this bisection is arrived at by three steps, each of which has a probable error of $\pm 0''{\cdot}022$; consequently the probable error of $\beta = 0''{\cdot}022 \times \sqrt{3}$; and the probable error of the middle division $r_0 = \sqrt{r^2 + \beta^2}$.

The results are for

101	107	113	119	125	131	137	145
95	89	83	77	71	65	59	53
$\pm 0''{\cdot}049$	$\pm 0''{\cdot}060$	$\pm 0''{\cdot}070$	$\pm 0''{\cdot}078$	$\pm 0''{\cdot}085$	$\pm 0''{\cdot}092$	$\pm 0''{\cdot}098$	$\pm 0''{\cdot}014$

These are the maximum errors in each 6-division group, and it is easy to interpolate the values of r for the other divisions from these values found above, and the values of r for the limiting divisions of the group.

These interpolations are made in the accompanying table, which now represents the probable error of the determination of division error for each division of the scale.

The errors of both scales having been determined in the same way, the probable errors of the determination are indentical for both scales.

TABLE OF r FOR EACH DIVISION OF THE HELIOMETER SCALE, BEING THE PROBABLE ERROR OF THE DETERMINATION OF THE DIVISION ERROR OF EACH DIVISION.

No. of division	Derived from P.E. of length of 6-division space, reckoning backwards from 50	Derived from interpolation of P.E. of length of 1-division space	No. of division	Derived from P.E. of length of a 12-division space, reckoning from 74	Derived from P.E. of middle point and P.E. of bisection of 12-division space	Derived from P.E. of middle point and P.E. of bisection of 6-division space	Derived from P.E. of adjacent division and P.E. of length of 1-division space	No. of division	P.E. of 98, brought forward	Derived from P.E. of length of 6-division space, reckoned forward from 98	Derived from interpolation of P.E. of length of 1-division space
2	±″·101	″ ...	50	±″·018	″ ...	″ ...	″ ...	98	±″·018	″ ...	″ ...
3	...	·102	51	...	...	...	±·033	99	...	...	·029
4	...	·103	52	...	...	...	±·038	100	...	...	·36
5	...	±·104	53	...	...	±·027	...	101	...	...	±·049
6	...	·101	54	...	...	...	±·038	102	...	...	·045
7	...	·098	55	...	...	...	±·039	103	...	...	·042
8	±·094	...	56	...	±·028	...	...	104	...	±·039	...
9	...	·095	57	...	...	...	±·039	105	...	...	·047
10	...	·096	58	...	...	...	±·037	106	...	...	·054
11	...	±·098	59	...	...	±·025	...	107	...	...	±·060
12	...	·095	60	...	...	...	±·037	108	...	...	·057
13	...	·091	61	...	...	...	±·030	109	...	...	·055
14	±·087	...	62	±·013	...	...	...	110	...	±·053	...
15	...	·086	63	...	...	...	±·030	111	...	...	·059
16	...	·090	64	...	...	...	±·036	112	...	...	·065
17	...	±·092	65	...	...	±·024	...	113	...	...	±·070
18	...	·088	66	...	...	...	±·036	114	...	...	·068
19	...	·084	67	...	...	...	±·037	115	...	...	·066
20	±·080	...	68	...	±·025	...	...	116	...	±·064	...
21	...	·081	69	...	...	...	±·037	117	...	...	·069
22	...	·083	70	...	...	...	±·035	118	...	...	·074
23	...	±·085	71	...	...	±·022	...	119	...	...	±·078
24	...	·080	72	...	...	...	±·035	120	...	...	·076
25	...	·076	73	...	...	...	±·027	121	...	...	·074
26	±·072	...	74	±·000	...	...	...	122	...	±·072	...
27	...	·074	75	...	...	...	±·027	123	...	...	·076
28	...	·076	76	...	...	...	±·035	124	...	...	·080
29	...	±·078	77	...	...	±·022	...	125	...	...	±·085
30	...	·074	78	...	...	...	±·035	126	...	...	·083
31	...	·069	79	...	...	...	±·037	127	...	...	·081
32	±·064	...	80	...	±·025	...	...	128	...	±·080	...
33	...	·066	81	...	...	...	±·037	129	...	...	·084
34	...	·068	82	...	...	...	±·036	130	...	...	·088
35	...	±·070	83	...	...	±·024	...	131	...	...	±·092
36	...	·065	84	...	...	...	±·036	132	...	...	·090
37	...	·059	85	...	...	...	±·030	133	...	...	·086
38	±·053	...	86	±·013	...	...	...	134	...	±·087	...
39	...	·055	87	...	...	...	±·030	135	...	...	·091
40	...	·057	88	...	...	...	±·037	136	...	...	·095
41	...	±·060	89	...	...	±·025	...	137	...	...	±·098
42	...	·054	90	...	...	...	±·037	138	...	...	·096
43	...	·047	91	...	...	...	±·039	139	...	...	·095
44	±·039	...	92	...	±·028	...	...	140	...	±·094	...
45	...	·042	93	...	...	...	±·039	141	...	...	·098
46	...	·045	94	...	...	...	±·038	142	...	...	·101
47	...	±·049	95	...	...	±·027	...	143	...	...	±·104
48	...	·036	96	...	...	...	±·038	144	...	...	·103
49	...	·029	97	...	...	...	±·033	145	...	...	·102
50	±·018	...	98	±·018	...	...	...	146	...	±·101	...

The next step is to consider what systematic errors may exist to affect the probable errors thus arrived at.

Two such questions seem to require settlement.

1. Do the divisions, when viewed at different distances from the centre of the field, present the same appearance—in other words, would the division error, as determined by 12-division and 6-division spaces, be the same, since the one is viewed at six divisions', the other at three divisions', distance from the centre of the field ?

2. Will the divisions give different results for division error to different observers ? Is there, in fact, a *personality* in the determination of division error, and does this *personality* vary with the same observer by time or other causes ?

The first of these questions admits of a very direct answer.

The first, second, and sixth series of the lengths of the fundamental 12-division spaces $\alpha, \beta, \gamma, \delta$, &c., were determined by the measurement of spaces of twelve divisions, whilst the results for the same spaces by the fifth, seventh, and tenth series were got by the summation of measured spaces of six divisions each.

The mean values (having regard to weight) so obtained are in revolutions—

	α	β	γ	δ	α_1	β_1	γ_1	δ_1
By 12-division spaces	+·0087	−·0075	+·0036	−·0048	+·0039	+·0022	−·0039	−·0024
By 6-division spaces	+·0101	−·0071	+·0006	−·0033	+·0031	+·0005	−·0023	−·0012

The differences from the final values are—

12-division spaces	−·0005	−·0002	+·0014	−·0006	+·0003	+·0007	−·0007	−·0005
6-division spaces	+·0009	+·0002	−·0017	+·0009	−·0005	−·0010	+·0009	+·0007

These differences indicate an agreement within the limits of the probable error of the determinations, and we are entitled to conclude that no sensible systematic error is introduced from the divisions not having been observed in the centre of the field.

The second question is easily answered so far as personality is concerned.

The influence of a uniform personality can have no effect, since the whole of the division errors, as well as all the investigations made with the heliometer, were made by Mr. Gill.

It is easy to suppose that personality does exist, and that it may change, for very few, if any, of the divisions are, when minutely examined, perfectly clean lines bounded by absolutely straight edges. Owing to minute variations, probably in the texture of the metal, and probably also to the after removal of the 'burr' of the division (we believe done by rubbing with fine charcoal), most of the divisions show minute *bulgings* at some points, or not an absolutely clearly defined edge, and thus different points of the division would have a different division error. Mr. Gill strictly followed the same plan throughout—viz. he endeavoured to arrange the webs symmetrically with respect to the estimated centre of the length of each division.[1]

That Mr. Gill's habit of observing the scale did not materially change, is evinced by the

[1] In another instrument of the same kind, or in any scale whose errors must be accurately investigated, it would be well to have a pair of fine parallel lines about $\frac{1}{50}$th of an inch apart, ruled at right angles to the divisions; after the division has been performed, the portion of the division limited by these lines to be considered the standard divisions.

agreement of the lengths of the 12-division spaces determined by the Tenth Series as compared with the mean of the whole.

The Tenth Series was made in the beginning of the year 1876, all the other series in 1874, and the whole of the observations depending on them were made between these epochs.

The results of the investigations for division error would therefore appear to be free from systematic error, but if the reader compares the probable error of the individual series, he will find that the final probable error derived from a combination of series exceeds the probable error due to the combination calculated from the probable errors of the individual series.

Not unduly to extend this discussion, it is sufficient to state here that the following general conclusions have been arrived at:—

1. There is a limited accuracy in the determination of the error of division of each division, beyond which no amount of observation will strengthen the result.

2. This limit of accuracy is different for different divisions, and seems to depend on the perfection of the surface and the cleanness of the cut.

3. That for any division the limit of accuracy is from one-third to one-fourth the probable error of a single careful bisection.

4. The probable error of one careful bisection varies for the heliometer in question from $\pm 0^{r}\cdot002$ to $\pm 0^{r}\cdot004$, and, in consequence, in a scale and microscope of the quality of the heliometer in question, it is possible to attain to an investigation of each division error with an accuracy from $\pm 0''\cdot02$ to $\pm 0''\cdot03$, but beyond this no amount of observation can be depended on to increase the certainty.

It is, however, to be noted that in each complete observation (see pp. 13, &c.) two divisions of Scale *A* and two divisions of Scale *B* are read in each of the two positions of the segments, so that, so far as division error is concerned, the probable error of the result is made to depend on eight divisions, and is

$$\frac{\pm 0''\cdot028}{\sqrt{8}} = \pm 0''\cdot0088,$$

provided that each division error is known with the utmost accuracy with which it is capable of being determined.[1]

[1] This result would be best arrived at, not by reiterated observations of the length of the same distances, but rather by arriving at the result by many different ways. To this end the micrometer should have a movable eye-piece, as in most parallel wire micrometers attached to equatorials. This eye-piece should be movable by a quick-motion screw, so that its position could be changed without disturbing the micrometer more than is done in the ordinary course of measuring.

It would now be possible to observe very much greater spaces, and probably the most convenient arrangement would be to have a series of webs arranged symmetrically with respect to the central webs, embracing spaces of 24, 18, 16, 12, 9, 8, and 6 divisions; for a total length of scale of 144 divisions these would subdivide the scale into 6, 8, 9, 12, 16, 18, and 24 parts respectively.

Two hours' observation of each series in each of these measures would, combining the series with proper weights, give the errors of the same division of the scale with extreme accuracy. The scale should extend three divisions in either direction beyond the fundamental 144 divisions, so that a similar complete comparison of the 24-, 18-, 16-, 12-, 9-, 8-, and 6-division spaces may be made, commencing at each of the three divisions above and below the first division of the fundamental scale. The whole of these would so overlap and interlace as to afford, on a proper reduction, a complete determination of the division error of each division on the scale, and the whole need not occupy more than 100 hours, though the series would require to be spread over two months, as an observer cannot continue more than two hours per day on such work without great risk of injury to the eyesight.

We mention this proposal here because in future heliometers it would be so very easy to introduce this small change in the construction of the microscope; and also to call attention to the fact that the method of successive

In the investigation actually made, much has been sacrificed to obtaining the division error of the fundamental scale with very small probable error.

The actual sum of the squares of the probable errors of the determination of division error for the 50 divisions of the fundamental scale is ·024380, whence the probable error of a division-error determination taken at hazard in the fundamental scale is

$$\pm 0''{\cdot}031,$$

and the probable error due to unknown division-error in a complete double measure made by the fundamental scale is

$$\frac{0''{\cdot}031}{\sqrt{8}} = \pm 0''{\cdot}011.$$

In the extreme parts of the scale the same accuracy has not been attained; and, indeed, if the actual values r given in the table really entered into the reductions of the observations of Juno, the effect would be very seriously to increase the probable error.

This, however, is not the case.

The comparatively large values of r, amounting near the extremities of the scale to $\pm 0''{\cdot}10$, arise chiefly from cumulative error, due to the method by which the division errors were determined.

What we are really concerned to know in the Juno reductions *is, not what is the probable error of the absolute distance of the planet from the star of comparison, but what is the probable error of the measured apparent distance traversed by Juno betweeu the evening and morning observations.*

This space never exceeds a change of six divisions in the scale readings.

The maximum probable error in such a case will be the combined effect of the probable error of the determination of the length of a 6-division space and of the bisection of a 6-division space

$$= \sqrt{(\cdot 035)^2 + 3\,(\cdot 022)^2} = \pm 0''{\cdot}040;$$

or for a complete double observation

$$\pm \frac{0''{\cdot}040}{\sqrt{8}} = \pm 0''{\cdot}014.$$

The details of all the observations made for division error are bound together, and form a folio volume lettered 'Observations for Division Error of the Heliometer Scale,' and this volume is deposited along with the other original observations of the expedition.

bisection (even were it possible in the heliometer scale without introducing the use of different microscopes and different illumination) is not the best in the case where a very long scale has to be subdivided, from the fact that the error of each successive bisection is perpetuated, and that no amount of observing can secure the thus required accuracy in the original bisections.

CHAPTER III.

THE ERRORS OF THE SCREW.

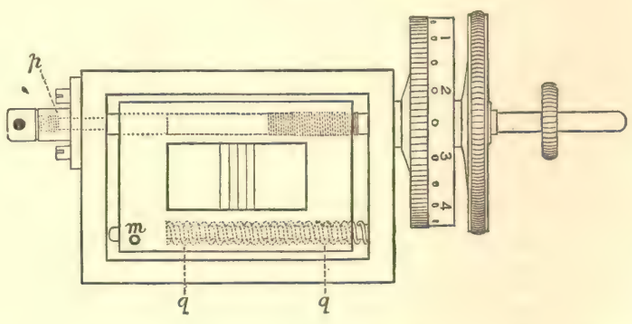
HAVING constructed a table for correction of the errors of the scale, we have still to consider the correction of errors which may arise in the subdivision of the scale by means of the micrometer.

The construction of Repsold's micrometer, here shown, differs from the ordinary construction of the filar micrometer in use in England.

In the usual form a brass frame moves in a slide, and across the frame the spider lines are stretched.

One end of this frame is left of considerable thickness (in some cases made of the form of a tuning-fork with a thick handle), and in this handle, or thickened end, a hole is tapped to receive the micrometer screw thread. The micrometer screw passes through the end of the box surrounding the slide, and enters the tapped hole, so that when the screw is turned till its shoulder comes against the box, motion is communicated to the slide. When the slide is moved spiral springs are compressed, so that when the screw is turned till the webs occupy their normal position, the shoulder of the screw is pressed strongly against the end of the box, and thus to a great extent 'loss of time' is prevented.

FIG. 6.



The shoulder is by some makers made square, like the shoulder of an ordinary clock pivot; by others it is a carefully turned steel cone, or rather portion of a sphere, working in a hollow cone attached to the box. The French makers, on the other hand, attach the screw to the end of the slide, and convert the micrometer head into a revolving matrix bearing against the end of the micrometer box.

These forms of construction all have the advantage that the position of the screw is symmetrical, and thus that only those portions of the screw errors enter into the measurement of distances which can be resolved along the axis of the screw.

This is not the case with the Repsold micrometer, applied to the heliometer represented in

the accompanying drawing. Here the wire frame is mounted on the screw itself; the limiting point of the motion is at *p*, where the end of the screw bears upon on agate plane,[1] and is kept in bearing against this plane by the spiral spring *q*.

Rotation of the wire frame is prevented by the small studs *m m*, which fit accurately but easily in the micrometer box.

The wire frame will, therefore, in the Repsold micrometer follow absolutely and accurately the motion of the screw.

If the screw is bent, so that, for example, the end next the screw head is raised and that next the end *p* lowered, a twist will be given to the wire frame, and the centre of the wire will be moved nearer to the micrometer head than it should be, while the reverse effect will follow when the head has been turned through 180°. The effect of a similar error on the other micrometers described would be of a much less amount. They are, however, liable to errors of another character.

If the shoulder is spherical, fitting into a hollow cone on the box, an almost inconceivable accuracy of construction is implied in drilling the matrix of the screw in the slide, and the axis of the cone, *absolutely* parallel to the line of motion of the slide. The most minute failure from perfect accuracy in this respect has the effect of bringing different portions of the spherical shoulder to bear on different parts of the cone for different revolutions, and introducing errors of a character by no means easy to deal with.

If the shoulder is square, the hole in the end of the box may be left sufficiently wide to allow for a small error in the parallelism of the screw matrix with the motion of the slide, but the smallest bend in the screw causes the shoulder no longer to bear *flat*, but to ride on its edge, introducing an extremely uncertain form of error.

If the hole is left a little wide, unless the shoulder is cut hollow (it is practically impossible to make an absolutely square shoulder), side motion will cause different parts of the shoulder to bear, and introduce another form of uncertain error.

In addition to these objections there always is and will be the greater objection of employing as a delicate-contact measuring surface one that is exposed where oil is used. Dust and oil *will* arrange themselves in layers of variable and uncertain thickness, and defy all attempts to secure absolutely consistent results.

If we are to regard the most perfect instrument, *not that which has absolutely the smallest errors, but which reproduces its errors with the most perfect consistency*, most undoubtedly Repsold's form of micrometer is the best.

The *point d'appui* is a small hardened and polished bearing,[2] requiring little lubrication, and perfectly protected from dust; the errors of the screw (some of them exaggerated, certainly) are faithfully reproduced, and consequently determinable, and beyond this the work to be done by the screw is reduced to a minimum, no slide friction having to be overcome.

[1] We *believe* it is an agate plane—it should be so—but we dare not remove the end bearing to examine it, because it is probable we could not replace the plane *precisely* with the same relation to the divided drum-head, and thus the character of the periodic errors would be changed.

When this plane is removed and replaced, a reinvestigation of the screw errors becomes necessary.

[2] Micrometer screws are not made of hardened steel; the attempt to harden them after they are made would probably bend them and destroy their accuracy. We do not know if attempts have been made to cut screws from hardened steel; but even were it possible to have screws hardened at the shoulder, they would be very brittle and apt to snap off. The point of a screw, on the other hand, can be hardened readily, and left and used so without risk.

Thus the '*feel*' of the screw is perfect, and the observer has the satisfactory consciousness that there is no sticking of slide or other failure to answer to the bisection he has made.

With this micrometer, as well as every other micrometer yet made, it is always necessary to finish a measure with the final motion against the spring—that is, the final motion must cause the slide to approach the head.

No spring seems to be able decidedly to eliminate 'loss of time;' the last traces of this appear to be due to the arrangement of the film of oil between the screw and matrix. In every measure of every kind made with the heliometer, the precaution has always been taken to finish the measure 'against the spring;' and if the eye on a second examination is dissatisfied with the bisection, the screw is turned back from a half to a quarter of a turn, and the wire is brought up to bisection again against the spring till the eye is satisfied.

The errors to which such a micrometer is subject may be divided into two classes—those which repeat themselves with each revolution, and those which may be considered to vary from revolution to revolution.

The most obvious example of the first of these cases would be the case where the agate plane is not at right angles to the axis of the screw, and the point of the screw eccentric. In addition to this we can conceive the end of the screw not to be a point, but an eccentric figure, and we may also conceive errors in the plane.

In all cases of moderately good construction, experience has also shown that all sensible errors are included in the above expression, without taking terms higher than 2 cos and 2 sin into account.

Again, if the screw is cut in an engine when the pivots are not absolutely true, this would introduce another periodic error; or if the screw is passed through a tap, its axis being in the smallest degree inclined to the axis of the matrix, this will cause periodic error.

Whatever the complication of sources of error we may so conceive, those errors which repeat themselves with each revolution must be a function of the reading of the micrometer head, and can be represented by the periodic function

$$a_1 \cos u + b_1 \sin u + a_2 \cos 2u + b_2 \sin 2u + \&c.,$$

where u is the reading of the micrometer head; a_1, b_1, &c., are coefficients to be determined.

Errors of the second description may arise from many causes.

Suppose a screw is being cut, and the temperature of the steel is gradually raised as the operation proceeds, then the thread intervals which have been cut at the higher temperature will, on cooling, be shorter than those cut at first.

If the rise of temperature is gradual, we may consider that the screw correction is proportional to the number of revolutions.

If the screw has been used some considerable time, then—in the case of our micrometer, for example—those revolutions which work in the matrix corresponding to revolution 2·0 will be most worn, because in every measure that part of the screw will be employed, whilst towards 0·0 and 4·0 the screw is only occasionally used.

The effect of this is that, if wear takes place, the screw will be most worn at the parts corresponding to revolution 2·0. This would introduce terms depending on the number of revolutions, and their squares; and if the screw was not of uniform hardness, one side or one part might wear more than another introducing terms of a still higher order.

In the Repsold micrometer, if we suppose the screw bent so that the greatest deviation from the axis of rotation is at the middle point between the bearings of the screw, and also if the bearings of the matrix are symmetrically arranged with respect to the point of greatest bend, then a small rotation of the micrometer head will produce no change in the angle between the spider web and the axis of rotation, because both ends of the matrix are equally moved in the direction of the length of the spider web.

When, however, the ends of the matrix are not symmetrical with the point of greatest bend, then one end of the matrix will be more affected than the other by the eccentricity of the screw, and a couple will be produced, changing the angle between the spider webs and the axis of rotation of the screw, and producing an error at the middle point of the web depending on the sine of the indication of the head and the square of the number of revolutions from the point of maximum bend.[1]

As all these errors are small, we can suppose them to be capable of expression by

$$a_1 \cos u + b_1 \sin u + a_2 \cos 2u + b_2 \sin 2u + n_1 r + n_2 r^2 + \&c.,$$

when n_1 and n_2 are coefficients to be determined, and r_1 the number of revolutions reckoned from 0.

The following table is the result of the last of several series made for determining the errors of the screw.

In the earlier series only one revolution was examined at a time; these series, therefore, only permit examination of periodic error.

It was supposed at first that in so short a portion of a screw as four revolutions it would not be necessary to take the terms $n_1 r$ and $n_2 r^2$ into account, but the considerations previously quoted, as well as internal evidence of former series, seemed to point to the necessity for a simultaneous investigation of all four revolutions.

Two of the wires separated almost exactly $0^r{\cdot}4$ were used.

A black speck on Scale *A* was first bisected by one of these wires, and then by the other, the head reading approximately $0^r{\cdot}0$ and $0^r{\cdot}4$ for the two bisections. The micrometer was now set at 0·1, and the scale moved by the slow-motion handle till the speck was again bisected by the first web; then the micrometer screw was put back about half a turn, and the first web brought up carefully to correct bisection of the speck, and then the speck was bisected by the second web. These readings will be approximately $0^r{\cdot}1$ and $0^r{\cdot}5$.

In this way the distance between the webs is measured by forty symmetrically disposed different parts of the screw, and then, to eliminate the effects of changes by temperature, the observations are repeated in the reverse order, beginning to measure at $3^r{\cdot}9$ and backwards to the measures beginning $0^r{\cdot}0$. Such a series of 80 measures (160 bisections) was all that

[1] This error is the most objectionable of any in the employment of the heliometer, because its amount will vary with the distance of the point of the web used from the axis of rotation of the screw, and therefore would be different for the two scales, since both are measured by different parts of the web.

It will be found, from the investigation of the screw, that the whole amount of this error is excessively small, and that the difference of its amount in the two scales will be imperceptible; still this only results from the great perfection of the screw, and in another instrument it would be desirable to lengthen the micrometer and place the webs at the end of the box, mounting them on forks, and make the *point d'appui* inside the box and the micrometer screw symmetrical with the web frame. The large errors found by Oudemans in some of Repsold's screws are probably due to this cause.

the eye could then bear at a time, the accurate bisection of these specks being somewhat trying and fatiguing.

The following day, or the afternoon of the same day, a similar set was made on a speck on Scale *B*, and the mean of the four measures so made constituted a complete series.

Three such series were made, the results of which are given in the accompanying tables.

The results, therefore, rest on 960 bisections.

APRIL 4 AND 5, 1876.

Revolution	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Mean
0	·402	·404	·403	·410	·401	·402	·394	·395	·398	·394	·4003
1	·407	·403	·401	·403	·403	·405	·399	·394	·394	·394	·4003
2	·398	·409	·408	·400	·404	·400	·397	·401	·395	·404	·4016
3	·402	·401	·401	·399	·401	·396	·399	·400	·395	·398	·3992
Means .	·4023	·4043	·4033	·4030	·4023	·4008	·3973	·3975	·3955	·3975	·40035

MARCH 29 AND 30, 1876.

Revolution	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Mean
0	·404	·407	·403	·403	·406	·399	·397	·399	·403	·400	·4021
1	·404	·406	·405	·403	·404	·398	·399	·397	·393	·399	·4008
2	·398	·399	·408	·405	·395	·400	·394	·393	·398	·398	·3988
3	·400	·398	·401	·405	·398	·394	·406	·398	·391	·400	·3991
Means .	·4015	·4025	·4043	·4040	·4008	·3978	·3990	·3968	·3963	·3993	·40020

APRIL 2 AND 4, 1876.

Revolution	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Mean
0	·398	·405	·403	·405	·406	·408	·399	·397	·399	·400	·4020
1	·404	·406	·402	·407	·402	·400	·397	·395	·395	·400	·4008
2	·405	·401	·407	·396	·403	·398	·397	·397	·391	·399	·3994
3	·401	·398	·401	·399	·401	·392	·400	·394	·393	·400	·3979
Means .	·4020	·4025	·4033	·4018	·4030	·3995	·3983	·3958	·3945	·3998	·40003

Taking the means of all these we have—

Revolution	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Mean
0	·4013	·4053	·4030	·4060	·4043	·4030	·3967	·3970	·4000	·3980	·4015
1	·4050	·4050	·4027	·4043	·4030	·4010	·3983	·3953	·3940	·3977	·4006
2	·4003	·4030	·4077	·4003	·4007	·3993	·3960	·3970	·4947	·4003	·3999
3	·4010	·3990	·4010	·4010	·4000	·3940	·4017	·3973	·3930	·3993	·3987
Means .	·4019	·4031	·4036	·4029	·4020	·3994	·3982	·3967	·3954	·3989	·4002

Putting u equal to the smaller reading of the micrometer head, u_1 equal to the greater in the periodic terms where the indications of the head are expressed in arc, also $r =$ the smaller reading expressed in revolutions and decimals of a revolution from 0_1 and r_1 the larger, then the general expression for the true length of a space f will be

$$f = u_1 - u + a_1 (\cos u_1 - \cos u) + b_1 (\sin u_1 - \sin u) + a_2 (\cos 2u_1 - \cos 2u) b_2 (\sin 2u_1 - \sin 2u) + n_1 (r_1 - r_2) + n_2 (r_1^2 - r_2^2) + \&c.$$

Each measure would give an equation of condition of this form, in all 40 equations of condition, involving six unknown quantities, and the solution of these by the method of least squares will give the required coefficients.

Such a solution is laborious, and a sufficiently accurate one is given by eliminating in the first place the periodic errors, and obtaining from the residuals the values of n_1 and n_2.

This mode of solution is also convenient, enabling us to judge whether it is desirable to take into account the terms depending on n_1 and n_2, and whether it is necessary to extend the computation to terms of still higher order.

Bessel has shown ('Astronomische Untersuchungen,' vol. i. pp. 79–80) that the values of the coefficients a_1, b_1, a_2, b_2, &c., will be expressed by the following equations,[1] when the constant space has been measured beginning successively at ten symmetrically disposed points of the head :—

$$10a_1 \sin \tfrac{1}{2} f = \Sigma (u^1 - u - f) \sin (u + \tfrac{1}{2} f)$$
$$10b_1 \sin \tfrac{1}{2} f = -\Sigma (u^1 - u - f) \cos (u + \tfrac{1}{2} f)$$
$$10a_2 \sin f = \Sigma (u^1 - u - f) \sin (2u + f)$$
$$10b_2 \sin f = -\Sigma (u^1 - u - f) \cos (2u + f)$$

Where f may be taken as the mean of all the measured values of the constant space, and Σ is the usual expression of summation, $(u^1 - u - f)$ is of course the excess of the particular measure over the mean.

The calculation of the periodic error from the 10 mean values is, then, as follows :—

$$f = 0^r{\cdot}4002 = 144^\circ\ 45'.$$

Revolution	In degrees	$u^1 - u - f$	$(u^1 - u - f)$ (sin at $\frac{1}{2}f$)	$(u - u - f) \cos (u + \frac{1}{2}f)$	$(u^1 - u - f) \sin (2u + f)$	$(u^1 - u - f) \cos (2u + f)$
·0	$^\circ 0$	+ ·0017	+ ·00162	+ ·00051	+ ·00098	− ·00139
·1	36	+ ·0029	+ ·00275	− ·00091	− ·00173	− ·00232
·2	72	+ ·0034	+ ·00198	− ·00276	− ·00322	+ ·00109
·3	108	+ ·0027	− ·00002	− ·00270	+ ·00004	+ ·00270
·4	144	+ ·0018	− ·00107	− ·00145	+ ·00172	+ ·00053
·5	180	− ·0008	+ ·00076	+ ·00024	− ·00046	+ ·00065
·6	216	− ·0020	+ ·00190	− ·00063	+ ·00120	+ ·00160
·7	252	− ·0035	+ ·00204	− ·00285	+ ·00331	− ·00113
·8	288	− ·0048	− ·00003	− ·00480	− ·00006	− ·00480
·9	324	− ·0013	− ·00077	− ·00105	− ·00124	− ·00039
Sums			+ ·00916	− ·01640	+ ·00054	− ·00346

[1] The reader is referred to an admirable paper by Professor Kaiser on 'Micrometer Screws' in the *Archives Nierlandaises des Sciences*, vol. iv., where the proof of these formulæ is given in greater detail than by Bessel.

Professor Kaiser also points out with fulness and force the absolute necessity for the investigation of screw errors, the errors sure to result from the neglect of such a precaution, and shows that the best screws of the best makers are liable to very considerable errors.

Substituting these sums and the values of sin f and sin $\frac{1}{2}f$ in the four preceding equations, we obtain

$$a_1 = + \cdot00096\,;\ b_1 = + \cdot00172\,;\ a_2 + \cdot00009\,;\ b_2 = + \cdot00060.$$

Substituting these values in the equation

$$a_1 \cos u + b_1 \sin u + a_2 \cos 2u + b_2 \sin 2u = \text{correction for reading } u,$$

we get the mean periodic corrections for values of u.

For $u=$	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
Corrections	+ ·00105	+ ·00240	+ ·00221	+ ·00091	− ·00030	− ·00087	− ·00120	− ·00165	− ·00173	− ·00078

We have, therefore, for comparing calculated and observed corrections—

Micrometer head	Computed quantities			Observed values of u^1-u-f	Sum [1]	vv
	u^1	u	u^1-u			
·0	− ·00030	+ ·00105	− ·0014	+ ·0017	+ ·0003	·00000009
·1	− ·00087	+ ·00240	− ·0033	+ ·0029	− ·0004	·00000016
·2	− ·00120	+ ·00221	− ·0034	+ ·0034	·0000	·00000000
·3	− ·00165	+ ·00091	− ·0026	+ ·0027	+ ·0001	·00000001
·4	− ·00173	− ·00030	− ·0014	+ ·0018	+ ·0004	·00000016
·5	− ·00078	− ·00087	+ ·0001	− ·0008	− ·0007	·00000049
·6	+ ·00105	− ·00120	+ ·0023	− ·0020	+ ·0003	·00000009
·7	+ ·00185	− ·00165	+ ·0035	− ·0035	·0000	·00000000
·8	+ ·00221	− ·00173	+ ·0039	− ·0048	− ·0009	·00000081
·9	+ ·00091	− ·00078	+ ·0017	− ·0013	+ ·0006	·00000036
						·00000217

Revolution	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	− ·0003	+ ·0018	− ·0006	+ ·0032	+ ·0027	+ ·0029	− ·0013	+ ·0003	+ ·0037	− ·0005
1	+ ·0034	+ ·0015	− ·0009	+ ·0015	+ ·0014	+ ·0009	+ ·0003	− ·0027	− ·0023	− ·0010
2	− ·0013	− ·0005	+ ·0041	− ·0025	− ·0009	− ·0008	− ·0020	+ ·0003	− ·0016	+ ·0018
3	− ·0004	− ·0045	− ·0026	− ·0027	− ·0016	− ·0061	+ ·0037	+ ·0006	− ·0033	+ ·0008

The sum of the squares of these residuals is $0^r \cdot 00022576$.

According to the original formula, if we suppose the screw to require a correction depending on the number and square of the number of revolutions from zero, besides the mean periodic correction now determined, these residuals will be represented by

$$n_1 (u_1 - u) + n_2 (u_1^2 - u^2) = \text{residual.}$$

[1] u^1-u is the computed *correction*, u^1-u-f the observed excess; the sum, therefore, should be 0. The smallness of the sums show that the mean periodic error of the screw is almost perfectly represented by the formula.

Applying the mean period corrections so found to each of the individual forty values, the following residuals result.

Forming from the residuals 40 equations of this form, and solving by least squares, there result—

$$n_1 = -\cdot00318 \quad n_2 = +\cdot00075.$$

The complete formula for the correction to be applied to a screw-reading becomes therefore

$$+\cdot00096\cos u + \cdot00172\sin u + \cdot00009\cos 2u + \cdot00060\sin 2u - \cdot00318r + \cdot00075r^2.$$

This formula gives the following residuals o−c:—

Revolution	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	−·0014	+·0007	−·0016	+·0023	+·0016	+·0021	−·0021	+·0001	+·0032	−·0011
1	+·0029	+·0011	−·0014	+·0011	+·0011	+·0006	+·0002	−·0010	−·0021	−·0008
2	−·0012	−·0003	+·0040	−·0023	−·0006	+·0005	−·0015	+·0014	−·0010	+·0024
3	+·0001	−·0037	−·0019	−·0009	−·0007	−·0052	+·0038	−·0022	−·0023	+·0020

The sum of the squares of these residuals is now $0^r\cdot00015547$, as compared with $0^r\cdot00022576$, justifying the introduction of terms depending on the number and square of the number of revolutions.

From the formula the corrections for each $\frac{5}{100}$th revolution were computed, and to each correction was added the quantity +·0100, to avoid negative quantities; and the accompanying table was then formed by a graphic interpolation, giving the correction to be added to each screw-reading to correct for the error of the screw.

From these residuals we find that the formula represents the actual observations with a probable error $\pm 0^r\cdot0013$.

It would undoubtedly have been better to have repeated this examination, using a space nearly equal to one revolution; but we were unwilling at the time to dismount the micrometer, and risk breaking the existing webs, for the sake of introducing others.

It is to be remembered that the above residuals contain the combined residuals of the periodic computation as well as the terms depending on the number and square of the number of revolutions.

In order to arrive at any conclusion as to the probable errors due to neglect of the precaution to compare the lengths of the successive revolutions directly, the several determinations arrived at by summation must be compared.

The mean length of the constant space measured in each set in terms of the screw are given in the tables of the measures, and are for the three sets—

April 4 and 5	·40035
March 29 and 30	·40020
April 2 and 4	·40003

Subtracting the length of the constant space as measured by the different revolutions from the mean lengths, keeping each set by itself, because the run or value of the screw or interval may change from day to day, we get the following residuals :—

	Rev. 0	Rev. 1	Rev. 2	Rev. 3
April 4 and 5	+ ·0000	+ ·0000	+ ·0012	− ·0001
March 29 and 30 . . .	+ ·0019	+ ·0006	− ·0014	− ·0011
April 2 and 4	+ ·0020	+ ·0008	− ·0006	− ·0021
Mean . . .	+ ·0013	+ ·0005	− ·0003	− ·0011

The differences from mean are—

		vv
Revolution 0 . . .	− ·0013	·00000169
	+ ·0006	·00000036
	+ ·0007	·00000049
Revolution 1 . . .	− ·0005	·00000025
	+ ·0001	·00000001
	+ ·0003	·00000009
Revolution 2 . . .	+ ·0015	·00000225
	− ·0011	·00000121
	− ·0003	·00000009
Revolution 3 . . .	+ ·0010	·00000100
	± ·0000	·00000000
	− ·0010	·00000100
		·00000844

And probable error of 1 determination = ± 0″·00054.

The determination of relative length of the revolutions depends on three such determinations for each. The probable error of the determination of the length of a screw revolution is therefore

$$\frac{\pm\ ·00054}{\sqrt{3}} = \pm\ ·00031.$$

The extreme probable error that can arise from the cause in question will be the accumulation of this probable error over two revolutions—

$$= \pm\ ·00031 \times \sqrt{2} = \pm\ ·00044 = \pm\ 0''·011.$$

If we regard the formula as exactly representing the periodic errors, and regard the outstanding errors as accidental errors, then the formula will give the correction for periodic error with a probable error of

$$\frac{\pm\ ·0013}{\sqrt{40}} = \pm\ ·00022 = \pm\ 0''·005.$$

The sum of these is only ± 0″·016; and seeing that each complete measure involves 16 screw-readings at 8 generally different points of the screw, it is exceedingly improbable that any systematic error amounting to 0″·01, due to uncorrected screw error, can arise.

Revolution 0

·0	·00	·01	·02	·03	·04	·05	·06	·07	·08	·09
·0	·0111	·0112	·0114	·0115	·0116	·0117	·0118	·0119	·0120	·0121
·1	·0121	·0121	·0122	·0122	·0122	·0121	·0120	·0119	·0118	·0117
·2	·0116	·0115	·0113	·0112	·0110	·0109	·0107	·0105	·0103	·0102
·3	·0100	·0098	·0097	·0095	·0093	·0092	·0091	·0090	·0088	·0087
·4	·0086	·0085	·0084	·0083	·0082	·0081	·0080	·0079	·0078	·0078
·5	·0077	·0077	·0076	·0076	·0075	·0075	·0075	·0074	·0073	·0073
·6	·0072	·0071	·0071	·0070	·0069	·0068	·0067	·0067	·0066	·0066
·7	·0065	·0064	·0063	·0063	·0062	·0062	·0062	·0061	·0061	·0061
·8	·0061	·0061	·0061	·0061	·0062	·0063	·0064	·0065	·0067	·0068
·9	·0070	·0072	·0074	·0075	·0076	·0078	·0080	·0081	·0083	·0084

Revolution 1

·0	·00	·01	·02	·03	·04	·05	·06	·07	·08	·09
·0	·0086	·0088	·0089	·0091	·0093	·0094	·0095	·0096	·0097	·0098
·1	·0098	·0098	·0098	·0098	·0098	·0098	·0098	·0097	·0097	·0096
·2	·0095	·0094	·0093	·0092	·0090	·0089	·0087	·0086	·0083	·0082
·3	·0081	·0079	·0078	·0076	·0074	·0073	·0072	·0070	·0069	·0068
·4	·0067	·0066	·0065	·0064	·0063	·0063	·0062	·0062	·0061	·0061
·5	·0061	·0061	·0060	·0060	·0060	·0059	·0058	·0058	·0057	·0057
·6	·0056	·0056	·0055	·0055	·0054	·0054	·0053	·0053	·0052	·0052
·7	·0051	·0050	·0049	·0049	·0048	·0048	·0048	·0048	·0049	·0049
·8	·0050	·0051	·0051	·0052	·0052	·0053	·0054	·0055	·0056	·0057
·9	·0059	·0060	·0062	·0064	·0066	·0068	·0070	·0072	·0073	·0075

Revolution 2

·0	·00	·01	·02	·03	·04	·05	·06	·07	·08	·09
·0	·0077	·0078	·0080	·0082	·0083	·0085	·0086	·0087	·0088	·0090
·1	·0090	·0090	·0090	·0090	·0091	·0091	·0091	·0091	·0091	·0091
·2	·0091	·0090	·0089	·0087	·0085	·0083	·0081	·0080	·0079	·0077
·3	·0076	·0074	·0073	·0071	·0069	·0068	·0067	·0066	·0065	·0065
·4	·0064	·0063	·0063	·0062	·0061	·0061	·0061	·0060	·0060	·0059
·5	·0059	·0059	·0059	·0058	·0058	·0058	·0057	·0057	·0057	·0056
·6	·0056	·0056	·0056	·0056	·0055	·0055	·0054	·0054	·0053	·0053
·7	·0052	·0052	·0051	·0051	·0051	·0051	·0051	·0052	·0052	·0052
·8	·0053	·0053	·0054	·0054	·0055	·0056	·0058	·0059	·0060	·0061
·9	·0063	·0065	·0067	·0069	·0071	·0073	·0075	·0077	·0079	·0081

Revolution 3

·0	·00	·01	·02	·03	·04	·05	·06	·07	·08	·09
·0	·0083	·0085	·0087	·0088	·0090	·0092	·0094	·0095	·0096	·0097
·1	·0098	·0098	·0099	·0099	·0099	·0099	·0099	·0099	·0099	·0098
·2	·0098	·0098	·0097	·0096	·0095	·0094	·0093	·0092	·0090	·0088
·3	·0086	·0084	·0083	·0082	·0081	·0080	·0079	·0078	·0077	·0076
·4	·0076	·0075	·0074	·0073	·0073	·0073	·0073	·0073	·0073	·0073
·5	·0073	·0073	·0073	·0072	·0072	·0072	·0072	·0072	·0071	·0071
·6	·0071	·0071	·0071	·0071	·0071	·0071	·0070	·0070	·0070	·0069
·7	·0069	·0069	·0069	·0069	·0069	·0069	·0070	·0070	·0070	·0071
·8	·0071	·0072	·0072	·0073	·0074	·0075	·0076	·0078	·0080	·0082
·9	·0083	·0085	·0087	·0089	·0091	·0093	·0095	·0097	·0099	·0101

Revolution 4

·0	·00	·01	·02	·03	·04	·05	·06	·07	·08	·09
·0	·0104	·0105	·0107	·0109	·0111	·0113	·0114	·0115	·0117	·011[8]
·1	·0119	·0120	·0120	·0120	·0120	·0120	·0120	·0120	·0120	·0120
·2	·0120	·0120	·0119	·0118	·0117	·0116	·0115	·0114	·0113	·0112
·3	·0112	·0111	·0110	·0109	·0107	·0106	·0105	·0104	·0104	·0104
·4	·0103	·0103	·0103	·0102	...	...	...	...	...	...

CHAPTER IV.

METHOD OF OBSERVATION AND CALCULATION OF INSTRUMENTAL RESULTS.

THE approximate position angle, the distance in terms of the scale, and the Æ and Declination of the middle point between the objects having been calculated, the observer has no difficulty in setting the instrument, and finding at once the two objects nearly in contact in the field of view.

The observer then turns the position circle and handle for changing the separation of the lenses till both points are superposed.

In the earlier observations it was thus attempted to measure both position angle and distance at the same time.

This attempt was not successful. It is not a satisfactory observation to superpose one point upon another ; the eye cannot judge with sufficient accuracy of their exact superposition.

On further trial it was found best to measure the position angles and distances separately.

The stars having been nearly superposed, the handle for motion in distance was moved in alternate directions, and the images of the two stars were caused to pass and repass each other.

The eye was found to be extremely sensitive to the symmetrical passing and repassing of these minute points of light, the position-angle handle being turned till the eye was satisfied in this respect, the time was noted, and the position circle verniers were read off.

Next distance was measured in a similar manner. By small alternate motions of the position circle the images were made to cross and recross each other, and minute changes made with the distance handle until the eye was satisfied that the movement in position angle caused the images of the stars to cross and recross symmetrically. Time was then noted, and the scales read off.[1]

When a planet is observed, its proper motion often forms the most delicate slow motion ; so that in measuring distance, for example, the approximate coincidence having been made, the discs of star and planet are made to pass and repass each other by movement of the position-angle handle till the motion of the planet causes the discs to pass perfectly symmetrically ; then the time is noted, and the scales are read off.[2]

In judging of the symmetrical passing of two points or minute discs over each other, it was

[1] In the case of double stars it is better to arrange them thus :—● ○ ● ○, or ● ● ○ ○. In the first method a double distance is measured, in the second a half-distance. The first method is best for close, and the second for very wide, pairs ; but the latter plan is only admissible when the compound stars are nearly alike in colour and magnitude.

[2] In such an observation one naturally adopts the method usual in observing a very slow-moving circumpolar star—viz. to note mentally the instant when very near the required phase, as nearly as possible the exact phase, and, when just sure the phase is past, to form from the whole a mental judgment of the number of seconds from the last estimate till the time of true phase ; this is added to the seconds, counted as before.

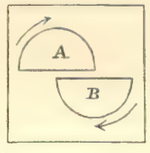
found of advantage to turn the head so that the line of apparent movement was in the direction of the line joining the observer's eyes, or at right angles to that line.

A measure of position angle and one of distance having been thus made, the segments are reversed (without reversing the position circle); another measure of distance is made, then another angle of position.

Now another angle of position is measured, but this time (if in the former case the final adjustment had been made by turning the position-angle handle as a right-handed screw) the final adjustment is given by turning the handle as a left-handed screw. Then another measure of distance is made (if in the former measures the final motion had been that of approach), with a final motion of separation to perfect the coincidence. The segments are then crossed again, and another distance and another position angle measured, the final motions for coincidence being the opposite of the motions in case of the two first measures.

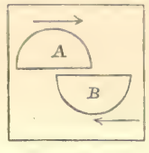
The order of observation will be better understood from the figures.

FIG. 7.



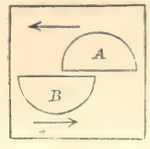
Position.

FIG. 8.



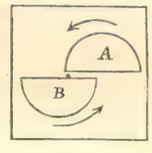
Distance.

FIG. 9.



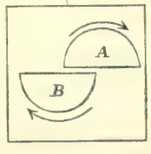
Distance.

FIG. 10.



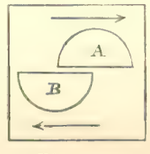
Position.

FIG. 11.



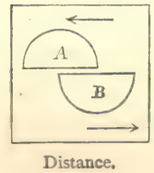
Position.

FIG. 12.



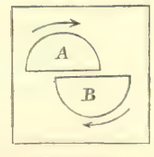
Distance.

FIG. 13.



Distance.

FIG. 14.



Position.

The arrow-heads indicate the direction of final movement.

Such an observation is complete, and constitutes *a group*.

The mean of the measures of such a group of distances is free from index error and from its progressive change.

The necessity for such symmetrical arrangement of the observations, to attain the highest accuracy, will afterwards be shown by the fact that the probable error of the mean of four such measures of distance as 8, 9, 12, 13, is less than half the probable error of one of them.

It is still more complete to combine two such groups, made with 180° difference of the position-circle readings.

In reading the scales the division preceding and the division following the pointer are read for each scale in the following order :—

1. Scale *A*, preceding division.
2. Scale *B*, preceding division.
3. Scale *B*, following division.
4. Scale *A*, preceding division.

Put M_p = the micrometer reading on the division preceding the pointer;
M_f „ „ „ following „

and D_p and D_f for the numbers of the divisions preceding and following the pointer.

(The reading on the preceding or higher-numbered division is the smaller reading of the micrometer); and remembering that one division of the scale = two normal screw-revolutions, the correction of run for one revolution will be $\frac{M_p - M_f}{2}$.

The usual method of reduction is to find the point of the scale opposite $2^r{\cdot}0$ for each scale.[1]

If there is no error of run, this point is obviously $D_f + (M_f - 2)$, where D_f is expressed in divisions, and $M_f - 2$ in screw revolutions.

It is most convenient to convert the scale readings into normal screw revolutions, and therefore the point opposite $2^r{\cdot}0$ expressed in screw revolutions from 0 is

$$2\,D_f + (M_f - 2);$$

or, including corrections for run, $= 2\,D_f + M_f - 2 + \frac{M_p - M_f}{2} \times (M_f - 2)$.

But the accidental errors in the readings and in the screw and division error corrections can be better eliminated as follows:—

The run can safely be assumed constant during the few observations of distance which constitute one group; so the mean of these four values of the run may be adopted as the run to be used for each scale (the runs for both scales have not been regarded as necessarily equal), and so are twice as accurate as the runs determined by the former plan, besides depending on four instead of two divisions only.

Again, if, instead of computing the distance of the following division from revolution $2{\cdot}0$, we compute the distance of the middle point between the two divisions from $2{\cdot}0$, two distinct advantages accrue.

1. The largest possible error of run to be applied cannot exceed the error in one revolution instead of two revolutions, and, in general, instead of being applied always with the same sign as in the former method, it is equally liable to be applied with either sign, and its influence will therefore be entirely eliminated in a series of observations where the distance measured is changing.

2. The reading of the scale relative to $2^r{\cdot}0$ will now depend on two readings instead of one, and of course also on two division-error determinations.

Thus $\frac{D_p + D_f}{2}$ is the middle point of the two divisions,

or $D_p + D_f$ expressed in normal screw revolutions.

The distance of this point from $2^r{\cdot}0$ is

$$\frac{M_p + M_f}{2} - 2.$$

[1] If the readings for both scales are alike when the optical centres are in coincidence, then the difference of these readings is the distance measured. This condition is of course seldom realised, and it becomes necessary to apply an index correction, which takes opposite signs in opposite positions of the lenses.

If r = the mean run deduced from the four observations, than the complete expression for the middle point between D_p and D_f from micrometer reading 2r·0 is in screw revolutions—

$$D_p + D_f + \left\{ \frac{M_p + M_f}{2} - 2 \right\} \times (1 + r).$$

This reading having been computed for each scale, the difference of the two readings corrected for index error is the distance measured.

When the segments are reversed, the sign of the index correction is obviously changed.

It has been found a matter of convenience, instead of changing the sign of the index correction, always to substract Scale B from Scale A, so that the resulting quantity

$$\text{Scale } A - \text{Scale } B$$

is alternately + and −, and the index correction has always the same sign. The sign of the distance + or − is found to be useful in distinguishing the position of the segments.

The accompanying form has been found a convenient one for applying division and screw corrections, and computing the distances.

It differs from the formula only in this, that $2D_f$ is used for $D_p + D_f$, and therefore the resulting reading of each scale is two revolutions smaller than the readings given by the formula, but the value of Scale A − Scale B is the same.

This value of 'Scale A − Scale B' is entered in the results.

These results have now to be corrected for refraction and true index error.

In the case of stars the refraction correction, calculated in terms of the screw, is applied to each individual observation, and then the algebraic sum of the + and − distances divided by the number of the observations is the index correction, to be applied throughout with such same sign as will render all the arithmetical distances nearly equal.

When a planet is observed the observations must be corrected for the known proper motion to the mean instant of each group, and then the refractions applied and the index correction computed, as in the case of a star. Or an approximate index correction is adopted, and the distance computed as before. The observed and calculated distances are computed, and a correction to the adopted index error computed from the resulting differences between calculated and observed distance.

If we are certain of no errors in any of the individual observations, and have no desire to investigate the probable errors of simple bisections, then this labour is quite unnecessary; the mean of the four values of Scale A − Scale B may be at once corrected for refraction, and the refraction (unless the zenith distance and the distance measured are very great) may be computed for the mean hour-angle of the group.

This method of reduction may be safely employed when the observer is in full practice and there are numerous measures of the same star to indicate any error of reading; but as seldom more than one measure of each object was obtained in the case of stars, and hardly any other means of perfectly checking the observations of Juno existed, each individual bisection has been rigidly reduced and compared with the calculated distance, and the results exhibited in the column marked C–O.

Another correction is sometimes required when the distances are small.

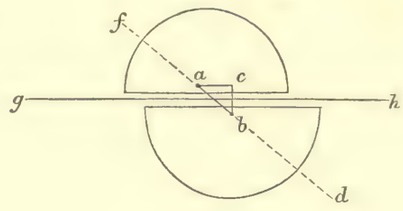
Suppose that the optical centres of the two segments, instead of being both on the line $g\,h$, are at a and b, and that in the position in which the segments are drawn the image of a star a is made exactly to coincide with that of a star b.

ROTATION No.				
OBJECTS OBSERVED.				
DATE.				

		Scale	Micrometer	Sums	Scale	Micrometer	Sums	Scale	Micrometer	Sums	Scale	Micrometer	Sums
Scale A	Preceding Division		,			,			,			,	
	Correction for Division Error (always +)		,			,			,			,	
	Correction for Screw Error (always +)		,	a_1 ,		,	a_1 ,		,	a_1 ,		,	a_1 ,
	Following Division		,		A	,		A	,		A	,	
	Correction for Division Error (always +)		,			,			,			,	
	Correction for Screw Error (always +)		,	a_2 ,		,	a_2 ,		,	a_2 ,		,	a_2 ,
	Mean of Micrometer Readings $= \frac{1}{2}(a_1 + a_2)$		=	,		=	,		=	,		=	,
	Run $= \frac{1}{2}$ (Decimals of a_1 − Decimals of a_2)		=	− ,		=	− ,		=	− ,		=	− ,
Scale B	Preceding Division		,			,			,			,	
	Correction for Division Error (always +)		,			,			,			,	
	Correction for Screw Error (always +)		,	b_1 ,		,	b_1 ,		,	b_1 ,		,	b_1 ,
	Following Division		,		B	,		B	,		B	,	
	Correction for Division Error (always +)		,			,			,			,	
	Correction for Screw Error (always +)		,	b_2 ,		,	b_2 ,		,	b_2 ,		,	b_2 ,
	Mean of Micrometer Readings $= \frac{1}{2}(b_1 + b_2)$		=	,		=	,		=	,		=	,
	Run $= \frac{1}{2}$ (Decimals of b_1 − Decimals of b_2)		=	− ,		=	− ,		=	− ,		=	− ,
	(Following Division of Scale A) $\times 2 + \frac{1}{2}(a_1 + a_2)$		=	,		=	,		=	,		=	,
	$\{\frac{1}{2}(a_1 + a_2) - 2\} \times$ Mean Run			− ,			− ,			− ,			− ,
	Sum = True Reading of Scale A		=	,		=	,		=	,		=	,
	(Following Division of Scale B) $\times 2 + \frac{1}{2}(b_1 + b_2)$		=	,		=	,		=	,		=	,
	$\{\frac{1}{2}(b_1 + b_2) - 2\} \times$ Mean Run			− ,			− ,			− ,			− ,
	Sum = True Reading of Scale B		=	,		=	,		=	,		=	,
	Scale A − Scale B		−	,		−	,		−	,		−	,
	Index Correction		−	,		−	,		−	,		−	,
	Sum = Instrumental Distance		−	,		−	,		−	,		−	,

It is obvious that instead of the line of displacement of the segments being, as it should be, $f d$, it is $g h$. Let us denote the angle of intersection of $f d$ and $g h$ by ψ.

FIG. 15.



Again, the measured distance along the line $g h$ (the line of the scales), instead of $a b$, is only $a c = a b \cos \psi$—that is to say, the true distance $a b$ = measured distance × secant ψ.

This angle ψ is obtained directly from the observations, and is half the difference of the readings of the position circle when observations are made; so that Scale A – Scale B is alternately + and −, for it is evident that an equal displacement of the lenses in the opposite direction will cause $f d$ to be inclined equally and oppositely to $g h$. Or the least optical distance of centres (which we shall call μ) is $c b$, and

$$\tan c b = \sin a b \tan \psi ;$$

or, without sensible error, μ = distance × tan ψ.

By this formula μ can be determined from several measures of double stars, or a great number of other observations, and ψ computed for observations where the direct measurement of ψ is impossible, as, for example, in the measures of Venus on the sun's disc.

On pp. 96–104 will be found a column showing the values of μ resulting from the observations during the whole period of the observations at Mauritius. It will be seen that μ seldom exceeds 3″, and the difference between *distance* and *measured distance* × secant ψ is quite insensible for all the zone observations, and only just barely sensible in some of the smallest distances in the Juno comparisons. In the double star observations ψ is always held to be determined by the observations, and the true distance to be = measured distance × secant ψ.

The computation of the position angles is simply to add the mean of the minutes of verniers I. and II. to the degrees of vernier I., and apply the corrections for refraction, ψ, and index error.

The correction for ψ is $$\tan \psi = \frac{\mu}{\text{distance.}}$$

Or the mean of a complete group is free from the correction for ψ, and is only affected by refraction and index error.

The correction for index error is discussed at p. 66.

When only one vernier has been read, the degrees proper to vernier I. are entered in the column for vernier I., and the minutes in the column actually observed.

The corrections for refraction have been computed by the formulæ of Bessel and Hansen.

Correction for refraction in distance = $s k [\tan^2 \zeta \cos^2 (p-q) + 1]$.

Correction for refraction in position angle

$$= - k \operatorname{cosec} 1' [\tan^2 \zeta \cos (p-q) \sin (p-q) + \tan \zeta \sin q \tan \delta_0].$$

Where s is the measured distance, ζ the true zenith distance, p the measured position angle, q the parallactic angle, δ_0 the declination of the middle point between the stars, and k is taken

from Table III., p. 198, Bessel, 'Astronomische Untersuchungen,' reprinted in Chauvenet's 'Astronomy,' vol. ii. Table C, pp. 572–575.

To find k from these tables—that is, to correct the log. a'' for the indications of the barometer and thermometer—the following table, copied and somewhat extended from the table given by Johnson (Radcliffe, 'Observations,' vol. xiv. p. 31), has been found sufficiently accurate and very convenient.

Thermometer	Barometer													
	30·50		30·40		30·30		30·20		30·10		30·00		29·90	
20° F.	+·0383	45	+·0368	45	+·0353	45	+·0339	45	+·0324	45	+·0310	45	+·0295	45
25	·0338	44	·0323	44	·0308	44	·0294	44	·0279	44	·0265	44	·0250	44
30	·0294	44	·0279	44	·0264	44	·0250	44	·0235	44	·0221	44	·0206	44
35	·0250	44	·0235	44	·0220	44	·0206	44	·0191	44	·0177	43	·0162	43
40	·0206	43	·0191	43	·0176	43	·0162	43	·0147	43	·0134	43	·0119	43
45	·0163	43	·0148	43	·0133	43	·0119	43	·0104	43	·0091	43	·0076	43
50	·0120	42	·0105	42	·0090	42	·0076	42	·0061	42	·0048	42	+·0033	42
55	·0078	42	·0063	42	·0048	42	+·0034	42	+·0019	42	+·0006	42	−·0009	42
60	+·0036	41	+·0021	41	+·0006	41	−·0008	41	−·0023	41	−·0036	41	·0051	41
65	−·0005	40	−·0020	41	−·0035	41	·0049	41	·0064	41	·0077	41	·0092	41
70	·0046	41	·0061	41	·0076	41	·0090	41	·0105	41	·0118	41	·0133	41
75	·0087	40	·0102	40	·0117	40	·0131	40	·0146	40	·0159	40	·0174	40
80	·0127	40	·0142	40	·0157	40	·0171	40	·0186	40	·0199	40	·0214	40
85	−·0167		−·0182		−·0197		−·0211		−·0226		−·0239		−·0254	

Thermometer	29·80		29·70		29·60		29·50		29·40		29·30		29·20	
20° F.	+·0280	45	+·0265	45	+·0250	45	+·0236	44	+·0221	44	+·0206	44	+·0191	44
25	·0235	44	·0220	44	·0205	44	·0192	44	·0177	44	·0162	44	·0147	44
30	·0191	44	·0176	44	·0161	44	·0148	44	·0133	44	·0118	44	·0103	44
35	·0147	43	·0132	43	·0117	43	·0104	43	·0089	43	·0074	43	·0059	43
40	·0104	43	·0089	43	·0084	43	·0061	43	·0046	43	+·0031	43	+·0016	43
45	·0061	43	·0046	43	+·0031	43	+·0018	43	+·0003	43	−·0012	43	−·0027	43
50	+·0018	42	+·0003	42	−·0012	42	−·0025	42	−·0040	42	·0055	42	·0070	42
55	−·0024	42	−·0039	42	·0054	42	·0067	42	·0082	42	·0097	42	·0112	42
60	·0066	41	·0081	41	·0096	41	·0109	41	·0124	41	·0139	41	·0154	41
65	·0107	41	·0122	41	·0137	41	·0150	41	·0165	41	·0180	41	·0195	41
70	·0148	41	·0163	41	·0178	41	·0191	41	·0206	41	·0221	41	·0236	40
75	·0189	40	·0204	40	·0219	40	·0232	40	·0247	40	·0262	40	·0276	40
80	·0229	40	·0244	40	·0259	40	·0272	40	·0287	40	·0302	40	·0316	40
85	−·0269		−·0284		−·0299		−·0312		−·0327		−·0342		−·0256	

Thermometer	Barometer													
	29·10		29·00		28·90		28·80		28·70		28·60		28·50	
20° F.	+·0176	44	+·0161	44	+·0146	44	+·0131	44	+·0116	44	+·0101	44	+·0086	44
25	·0132	44	·0117	44	·0102	44	·0087	44	·0072	44	·0057	44	+·0042	44
30	·0088	44	·0073	44	·0058	44	+·0043	44	+·0028	44	+·0013	44	−·0002	44
35	+·0044	44	+·0029	44	+·0014	44	−·0001	44	−·0016	44	−·0031	44	·0046	44
40	·0000	43	−·0015	43	−·0030	43	·0045	43	·0060	43	·0075	43	·0090	43
45	−·0043	43	·0058	43	·0073	43	·0088	43	·0103	43	·0118	43	·0133	43
50	·0086	42	·0101	42	·0116	42	·0131	42	·0146	42	·0161	42	·0176	42
55	·0128	41	·0143	41	·0158	41	·0173	41	·0188	41	·0203	41	·0218	41
60	·0169	41	·0184	41	·0199	41	·0214	41	·0229	41	·0244	41	·0259	41
65	·0210	40	·0225	40	·0240	40	·0255	40	·0270	40	·0285	40	·0300	40
70	·0250	40	·0265	40	·0280	40	·0295	40	·0310	40	·0325	40	·0340	40
75	·0290	39	·0305	39	·0320	39	·0335	39	·0350	39	·0365	39	·0380	39
80	·0329	39	·0344	39	·0359	39	·0374	39	·0389	39	·0404	39	·0419	39
85	−·0368		−·0383		−·0398		−·0413		−·0428		−·0443		−·0458	

In the case of zone stars it has been found convenient to compute the mean refraction in terms of the screw (1 revolution = 25″·729) for every half-hour, and in some cases for every quarter of an hour, and from these data to construct a curve on the French millimètre paper: 1 millimètre = ·001 revolution.

From this curve the refractions can be read off with every desirable accuracy and freedom from error.

To the logarithm of the mean refraction so found is to be added the number from the table corresponding to the readings of the barometer and thermometer; the result is the logarithm of the required refraction in terms of the screw.

The computation of ζ and q is much facilitated by the use of the accompanying auxiliary tables.

Fig. 16.

If P = the north pole, Z = the zenith, S = the star, M = a perpendicular from Z upon PS, N = the side PO of the triangle PZO—these tables give the values of N and cos M, computed for the latitude of Belmont for each hour angle; and then putting

π = PS = north polar distance, we have

$$\cos \zeta = \cos (\pi - N) \cos M ;$$
$$\cos q = \tan (\pi - N) \cos \zeta.$$

On pp. 75–78 are tables of the mean refractions, calculated for each of the zones observed at Mauritius and Dun Echt, for every quarter of an hour of hour angle.

The refractions in position angle have been computed in minutes and fractions of a minute.

The reader is now provided with every facility for checking calculations of each step of the measures.

TABLE FOR FACILITATING THE COMPUTATION OF ZENITH DISTANCES AT MAURITIUS (ARGUMENT, HOUR ANGLE).

Min.	0 h. and 12 h.		1 h. and 13 h.		2 h. and 14 h.		Min.
	N	Log. cos M	N	Log. cos M	N	Log. cos M	
0	69° 57′ 0″	0·00000	69° 18′ 6″	9·98677	67° 8′ 55″	9·94588	60
1	69 56 59	9·99999	69 16 46	9·98632	67 5 48	9·94494	59
2	69 56 57	9·99999	69 15 24	9·98586	67 2 38	9·94400	58
3	69 56 54	9·99997	69 14 1	9·98540	66 59 27	9·94305	57
4	69 56 50	9·99994	69 12 36	9·98493	66 56 13	9·94209	56
5	69 56 44	9·99991	69 11 9	9·98445	66 52 57	9·94112	55
6	69 56 37	9·99987	69 9 41	9·98397	66 49 39	9·94014	54
7	69 56 29	9·99982	69 8 12	9·98347	66 46 18	9·93916	53
8	69 56 20	9·99977	69 6 41	9·98297	66 42 55	9·93816	52
9	69 56 9	9·99970	69 5 9	9·98246	66 39 30	9·93716	51
10	69 55 57	9·99963	69 3 35	9·98194	66 36 2	9·93615	50
11	69 55 43	9·99956	69 1 59	9·98142	66 32 32	9·93513	49
12	69 55 29	9·99947	69 0 22	9·98088	66 28 59	9·93410	48
13	69 55 13	9·99938	68 58 44	9·98034	66 25 24	9·93306	47
14	69 54 56	9·99928	68 57 3	9·97980	66 21 46	9·93201	46
15	69 54 37	9·99918	68 55 22	9·97924	66 18 6	9·93095	45
16	69 54 18	9·99906	68 53 38	9·97868	66 14 24	9·92989	44
17	69 53 57	9·99894	68 51 54	9·97810	66 10 39	9·92881	43
18	69 53 35	9·99882	68 50 6	9·97752	66 6 51	9·92773	42
19	69 53 11	9·99868	68 48 19	9·97694	66 3 1	9·92663	41
20	69 52 46	9·99854	68 46 29	9·97634	65 59 8	9·92553	40
21	69 52 20	9·99839	68 44 38	9·97574	65 55 12	9·92442	39
22	69 51 53	9·99823	68 42 45	9·97513	65 51 14	9·92330	38
23	69 51 24	9·99807	68 40 50	9·97451	65 47 13	9·92217	37
24	69 50 54	9·99789	68 38 54	9·97388	65 43 9	9·92103	36
25	69 50 23	9·99772	68 36 56	9·97325	65 39 3	9·91988	35
26	69 49 51	9·99753	68 34 56	9·97260	65 34 53	9·91872	34
27	69 49 17	9·99734	68 32 55	9·97195	65 30 41	9·91756	33
28	69 48 42	9·99713	68 30 52	9·97129	65 26 26	9·91638	32
29	69 48 5	9·99693	68 28 47	9·97063	65 22 8	9·91519	31
30	69 47 27	9·99671	68 26 40	9·96995	65 17 48	9·91400	30
31	69 46 48	9·99649	68 24 32	9·96927	65 13 24	9·91279	29
32	69 46 8	9·99626	68 22 22	9·96858	65 8 57	9·91158	28
33	69 45 26	9·99602	68 20 10	9·96788	65 4 28	9·91035	27
34	69 44 43	9·99577	68 17 57	9·96717	64 59 55	9·90912	26
35	69 43 59	9·99552	68 15 41	9·96646	64 55 19	9·90788	25
36	69 43 13	9·99526	68 13 24	9·96573	64 50 40	9·90663	24
37	69 42 26	9·99499	68 11 5	9·96500	64 45 58	9·90536	23
38	69 41 38	9·99472	68 8 45	9·96426	64 41 13	9·90409	22
39	69 40 48	9·99443	68 6 22	9·96351	64 36 24	9·90281	21
40	69 39 57	9·99414	68 3 58	9·96276	64 31 33	9·90152	20
41	69 39 5	9·99385	68 1 31	9·96199	64 26 39	9·90022	19
42	69 38 11	9·99354	67 59 3	9·96122	64 21 40	9·89891	18
43	69 37 16	9·99323	67 56 33	9·96044	64 16 39	9·89759	17
44	69 36 19	9·99291	67 54 1	9·95965	64 11 34	9·89626	16
45	69 35 21	9·99258	67 51 27	9·95885	64 6 26	9·89492	15
46	69 34 22	9·99225	67 48 51	9·95805	64 1 14	9·89357	14
47	69 33 22	9·99190	67 46 13	9·95723	63 55 58	9·89221	13
48	69 32 20	9·99155	67 43 33	9·95641	63 50 40	9·89084	12
49	69 31 17	9·99120	67 40 51	9·95558	63 45 17	9·88946	11
50	69 30 12	9·99083	67 38 7	9·95474	63 39 51	9·88807	10
51	69 29 6	9·99046	67 35 22	9·95389	63 34 21	9·88667	9
52	69 27 58	9·99008	67 32 34	9·95303	63 28 48	9·88526	8
53	69 26 49	9·98969	67 29 44	9·95217	63 23 11	9·88384	7
54	69 25 39	9·98930	67 26 52	9·95130	63 17 30	9·88241	6
55	69 24 27	9·98889	67 23 57	9·95041	63 11 45	9·88097	5
56	69 23 14	9·98848	67 21 1	9·94952	63 5 56	9·87952	4
57	69 21 59	9·98807	67 18 3	9·94862	63 0 3	9·87806	3
58	69 20 43	9·98764	67 15 2	9·94772	62 54 7	9·87659	2
59	69 19 25	9·98721	67 12 0	9·64680	62 48 6	9·87511	1
60	69 18 6	9·98677	67 8 55	9·94588	62 42 1	9·87362	0
Min.	N	Log. cos M	N	Log. cos M	N	Log. cos M	Min.
	11 h. and 23 h.		10 h. and 22 h.		9 h. and 21 h.		

TABLE FOR FACILITATING THE COMPUTATION OF ZENITH DISTANCES AT MAURITIUS (ARGUMENT, HOUR ANGLE).

Min.	3 h. and 15 h.		4 h. and 16 h.		5 h. and 17 h.		Min.
	N	Log. cos M	N	Log. cos M	N	Log. cos M	
0	62° 42′ 1″	9·87362	53° 52′ 25″	9·76456	35° 20′ 36″	9·62356	60
1	62 35 53	9·87212	53 39 58	9·76241	34 54 1	9·62120	59
2	62 29 39	9·87060	53 27 22	9·76025	34 27 7	9·61885	58
3	62 23 22	9·86908	53 14 36	9·75809	33 59 54	9·61651	57
4	62 17 1	9·86755	53 1 41	9·75591	33 32 22	9·61418	56
5	62 10 35	9·86601	52 48 36	9·75372	33 4 30	9·61187	55
6	62 4 4	9·86445	52 35 21	9·75153	32 36 18	9·60957	54
7	61 57 30	9·86289	52 21 56	9·74932	32 7 46	9·60729	53
8	61 50 50	9·86131	52 8 21	9·74710	31 38 55	9·60502	52
9	61 44 7	9·85973	51 54 36	9·74488	31 9 44	9·60277	51
10	61 37 18	9·85813	51 40 40	9·74264	30 40 13	9·60053	50
11	61 30 25	9·85653	51 26 33	9·74040	30 10 22	9·59832	49
12	61 23 27	9·85491	51 12 16	9·73814	29 40 10	9·59612	48
13	61 16 25	9·85328	50 57 48	9·73588	29 9 39	9·59395	47
14	61 9 17	9·85164	50 43 9	9·73360	28 38 48	9·59180	46
15	61 2 5	9·84999	50 28 19	9·73132	28 7 37	9·58967	45
16	60 54 48	9·84834	50 13 17	9·72903	27 36 6	9·58756	44
17	60 47 25	9·84667	49 58 4	9·72673	27 4 15	9·58548	43
18	60 39 58	9·84500	49 42 39	9·72443	26 32 4	9·58343	42
19	60 32 25	9·84329	49 27 3	9·72211	25 59 33	9·58140	41
20	60 24 47	9·84159	49 11 14	9·71979	25 26 43	9·57941	40
21	60 17 4	9·83988	48 55 13	9·71745	24 53 33	9·57744	39
22	60 9 16	9·83815	48 39 0	9·71512	24 20 3	9·57550	38
23	60 1 22	9·83642	48 22 34	9·71277	23 46 14	9·57359	37
24	59 53 22	9·83467	48 5 56	9·71041	23 12 6	9·57172	36
25	59 45 17	9·83292	47 49 5	9·70805	22 37 39	9·56988	35
26	59 37 6	9·83115	47 32 0	9·70568	22 2 53	9·56807	34
27	59 28 50	9·82937	47 14 43	9·70331	21 27 49	9·56631	33
28	59 20 27	9·82758	46 57 12	9·70093	20 52 26	9·56457	32
29	59 12 59	9·82578	46 39 27	9·69854	20 16 45	9·56288	31
30	59 3 25	9·82397	46 21 29	9·69615	19 40 46	9·56123	30
31	58 54 44	9·82215	46 3 17	9·69375	19 4 30	9·55962	29
32	58 45 58	9·82032	45 44 51	9·69135	18 27 56	9·55805	28
33	58 37 5	9·81847	45 26 10	9·68894	17 51 5	9·55652	27
34	58 28 6	9·81662	45 7 15	9·68652	17 13 58	9·55504	26
35	58 19 1	9·81475	44 48 5	9·68411	16 36 35	9·55360	25
36	58 9 49	9·81287	44 28 41	9·68169	15 58 56	9·55221	24
37	58 0 31	9·81099	44 9 1	9·67926	15 21 2	9·55087	23
38	57 51 6	9·80909	43 49 6	9·67683	14 42 53	9·54957	22
39	57 41 34	9·80718	43 28 56	9·67440	14 4 30	9·54833	21
40	57 31 55	9·80526	43 8 30	9·67197	13 25 53	9·54714	20
41	57 22 9	9·80332	42 47 48	9·66953	12 47 2	9·54599	19
42	57 12 17	9·80138	42 26 51	9·66710	12 7 58	9·54490	18
43	57 2 17	9·79943	42 5 37	9·66466	11 28 42	9·54387	17
44	56 52 10	9·79746	41 44 7	9·66222	10 49 15	9·54288	16
45	56 41 56	9·79549	41 22 20	9·65978	10 9 36	9·54196	15
46	56 31 34	9·79350	41 0 16	9·65734	9 29 47	9·54108	14
47	56 21 4	9·79150	40 37 56	9·65490	8 49 47	9·54027	13
48	56 10 27	9·78949	40 15 19	9·65247	8 9 39	9·53951	12
49	55 59 43	9·78748	39 52 24	9·65003	7 29 21	9·53881	11
50	55 48 50	9·78545	39 29 12	9·64760	6 48 56	9·53817	10
51	55 37 49	9·78340	39 5 43	9·64517	6 8 24	9·53759	9
52	55 26 40	9·78135	38 41 55	9·64275	5 27 45	9·53707	8
53	55 15 24	9·77929	38 17 49	9·64033	4 46 59	9·53661	7
54	55 3 58	9·77722	37 53 26	9·63791	4 6 9	9·53621	6
55	54 52 25	9·77513	37 28 44	9·63550	3 25 14	9·53587	5
56	54 40 42	9·77304	37 3 44	9·63310	2 44 16	9·53559	4
57	54 28 51	9·77093	36 38 24	9·63070	2 3 15	9·53537	3
58	54 16 52	9·76882	36 12 47	9·62831	1 22 11	9·53522	2
59	54 4 43	9·76670	35 46 51	9·62593	0 41 6	9·53512	1
60	53 52 25	9·76456	35 20 36	9·62356	0 0 0	9·53509	0
Min.	N	Log. cos M	N	Log. cos M	N	Log. cos M	Min.
	8 h. and 20 h.		7 h. and 19 h.		6 h. and 18 h.		

TABLE FOR FACILITATING THE COMPUTATION OF ZENITH DISTANCES AT DUN ECHT.
(ARGUMENT = HOUR ANGLE.)

Min.	0 h. and 12 h.		1 h. and 13 h.		2 h. and 14 h.		Min.
	N	Log. cos M	N	Log. cos M	N	Log. cos M	
0	32° 50′ 25″	0·00000	31° 56′ 31″	9·99568	29° 12′ 15″	9·98342	60
1	32 50 24	9·99999	31 54 41	9·99554	29 8 33	9·98316	59
2	32 50 21	9·99999	31 52 50	9·99539	29 4 49	9·98289	58
3	32 50 17	9·99999	31 50 57	9·99524	29 1 2	9·98263	57
4	32 50 11	9·99998	31 49 3	9·99509	28 57 14	9·98236	56
5	32 50 3	9·99997	31 47 6	9·99494	28 53 24	9·98210	55
6	32 49 53	9·99996	31 45 8	9·99479	28 49 32	9·98183	54
7	32 49 41	9·99994	31 43 8	9·99463	28 45 38	9·98156	53
8	32 49 28	9·99992	31 41 6	9·99447	28 41 43	9·98128	52
9	32 49 13	9·99990	31 39 2	9·99431	28 37 45	9·98101	51
10	32 48 56	9·99988	31 36 56	9·99415	28 33 45	9·98073	50
11	32 48 37	9·99985	31 34 48	9·99398	28 29 43	9·98046	49
12	32 48 16	9·99982	31 32 39	9·99381	28 25 39	9·98018	48
13	32 47 54	9·99979	31 30 28	9·99365	28 21 34	9·97990	47
14	32 47 30	9·99976	31 28 14	9·99347	28 17 26	9·97962	46
15	32 47 4	9·99973	31 26 0	9·99330	28 13 17	9·97934	45
16	32 46 36	9·99968	31 23 43	9·99312	28 9 5	9·97905	44
17	32 46 6	9·99965	31 21 24	9·99295	28 4 52	9·97877	43
18	32 45 35	9·99961	31 19 3	9·99276	28 0 36	9·97848	42
19	32 45 2	9·99956	31 16 41	9·99258	27 56 19	9·97819	41
20	32 44 27	9·99951	31 14 16	9·99240	27 51 59	9·97790	40
21	32 43 50	9·99946	31 11 50	9·99221	27 47 38	9·97761	39
22	32 43 12	9·99941	31 9 22	9·99202	27 43 14	9·97732	38
23	32 42 31	9·99936	31 6 52	9·99183	27 38 49	9·97703	37
24	32 41 49	9·99930	31 4 21	9·99164	27 34 22	9·97673	36
25	32 41 5	9·99924	31 1 47	9·99144	27 29 53	9·97644	35
26	32 40 20	9·99918	30 59 11	9·99125	27 25 21	9·97614	34
27	32 39 32	9·99912	30 56 34	9·99105	27 20 48	9·97584	33
28	32 38 43	9·99905	30 53 55	9·99085	27 16 13	9·97554	32
29	32 37 52	9·99898	30 51 13	9·99065	27 11 36	9·97524	31
30	32 36 59	9·99891	30 48 30	9·99044	27 6 56	9·97494	30
31	32 36 4	9·99883	30 45 45	9·99023	27 2 15	9·97464	29
32	32 35 8	9·99876	30 42 59	9·99002	26 57 32	9·97434	28
33	32 34 9	9·99868	30 40 10	9·98981	26 52 47	9·97403	27
34	32 33 9	9·99860	30 37 19	9·98960	26 48 0	9·97373	26
35	32 32 7	9·99852	30 34 27	9·98939	26 43 11	9·97342	25
36	32 31 4	9·99843	30 31 33	9·98917	26 38 20	9·97311	24
37	32 29 58	9·99834	30 28 36	9·98895	26 33 27	9·97280	23
38	32 28 51	9·99825	30 25 38	9·98873	26 28 32	9·97249	22
39	32 27 42	9·99816	30 22 38	9·98851	26 23 34	9·97218	21
40	32 26 31	9·99806	30 19 36	9·98828	26 18 35	9·97187	20
41	32 25 18	9·99797	30 16 32	9·98806	26 13 34	9·97156	19
42	32 24 4	9·99787	30 13 26	9·98783	26 8 31	9·97124	18
43	32 22 47	9·99777	30 10 19	9·98760	26 3 26	9·97093	17
44	32 21 29	9·99766	30 7 9	9·98737	25 58 19	9·97061	16
45	32 20 9	9·99756	30 3 58	9·98713	25 53 10	9·97030	15
46	32 18 47	9·99745	30 0 44	9·98690	25 47 59	9·96998	14
47	32 17 24	9·99733	29 57 29	9·98666	25 42 46	9·96966	13
48	32 15 58	9·99722	29 54 12	9·98642	25 37 31	9·96934	12
49	32 14 31	9·99711	29 50 53	9·98618	25 32 14	9·96902	11
50	32 13 2	9·99699	29 47 32	9·98594	25 26 55	9·96870	10
51	32 11 31	9·99687	29 44 9	9·98569	25 21 34	9·96838	9
52	32 9 58	9·99674	29 40 44	9·98545	25 16 11	9·96806	8
53	32 8 24	9·99662	29 37 17	9·98520	25 10 46	9·96774	7
54	32 6 47	9·99649	29 33 48	9·98495	25 5 19	9·96741	6
55	32 5 11	9·99636	29 30 17	9·98470	24 59 50	9·96709	5
56	32 3 29	9·99623	29 26 45	9·98445	24 54 19	9·96677	4
57	32 1 47	9·99609	29 23 10	9·98419	24 48 46	9·96644	3
58	32 0 3	9·99596	29 19 34	9·98394	24 43 11	9·96612	2
59	31 57 18	9·99582	29 15 55	9·98368	24 37 35	9·96579	1
60	31 56 31	9·99568	29 12 15	9·98342	24 31 56	9·96546	0
Min.	N	Log. cos M	N	Log. cos M	N	Log. cos M	Min.
	11 h. and 23 h.		10 h. and 22 h.		9 h. and 21 h.		

TABLE FOR FACILITATING THE COMPUTATION OF ZENITH DISTANCES AT DUN ECHT—*continued.*
(ARGUMENT = HOUR ANGLE).

Min.	3 h. and 15 h.		4 h. and 16 h.		5 h. and 17 h.		Min.
	N	Log. cos M	N	Log. cos M	N	Log. cos M	
0	24° 31′ 56″	9·96546	17° 53′ 10″	9·94589	9° 29′ 2″	9·93035	60
1	24 26 15	9·96514	17 45 34	9·94558	9 19 56	9·93016	59
2	24 20 32	9·96481	17 37 56	9·94527	9 10 48	9·92997	58
3	24 14 47	9·96448	17 30 15	9·94497	9 1 40	9·92979	57
4	24 9 0	9·96415	17 22 34	9·94466	8 52 30	9·92961	56
5	24 3 11	9·96382	17 14 50	9·94436	8 43 19	9·92943	55
6	23 57 20	9·96349	17 7 5	9·94405	8 34 7	9·92925	54
7	23 51 27	9·96317	16 59 17	9·94375	8 24 55	9·92908	53
8	23 45 32	9·96284	16 51 29	9·94345	8 15 41	9·92891	52
9	23 39 35	9·96251	16 43 38	9·94315	8 6 25	9·92874	51
10	23 33 36	9·96218	16 35 45	9·94285	7 57 10	9·92857	50
11	23 27 36	9·96185	16 27 51	9·94256	7 47 53	9·92841	49
12	23 21 33	9·96151	16 19 56	9·94226	7 38 36	9·92825	48
13	23 15 28	9·96118	16 11 58	9·94197	7 29 17	9·92810	47
14	23 9 21	9·96085	16 3 59	9·94168	7 19 58	9·92794	46
15	23 3 12	9·96052	15 55 58	9·94139	7 10 37	9·92779	45
16	22 57 2	9·96019	15 47 55	9·94110	7 1 16	9·92764	44
17	22 50 49	9·95986	15 39 51	9·94081	6 51 54	9·92750	43
18	22 44 34	9·95953	15 31 45	9·94053	6 42 31	9·92736	42
19	22 38 17	9·95920	15 23 38	9·94024	6 33 7	9·92722	41
20	22 31 59	9·95886	15 15 28	9·93996	6 23 42	9·92709	40
21	22 25 38	9·95853	15 7 18	9·93968	6 14 17	9·92695	39
22	22 19 16	9·95820	14 59 5	9·93940	6 4 51	9·92681	38
23	22 12 51	9·95787	14 50 51	9·93912	5 55 24	9·92670	37
24	22 6 24	9·95754	14 42 35	9·93885	5 45 56	9·92658	36
25	21 59 56	9·95721	14 34 18	9·93857	5 36 28	9·92646	35
26	21 53 25	9·95688	14 25 59	9·93830	5 26 59	9·92634	34
27	21 46 53	9·95654	14 17 39	9·93803	5 17 29	9·92623	33
28	21 40 19	9·95621	14 9 17	9·93777	5 7 59	9·92612	32
29	21 33 42	9·95588	14 0 53	9·93750	4 58 28	9·92601	31
30	21 27 4	9·95555	13 52 28	9·93723	4 48 57	9·92591	30
31	21 20 24	9·95522	13 44 2	9·93697	4 39 24	9·92581	29
32	21 13 42	9·95489	13 35 34	9·93671	4 29 52	9·92571	28
33	21 6 58	9·95456	13 27 4	9·93645	4 20 18	9·92562	27
34	21 0 12	9·95423	13 18 33	9·93620	4 10 44	9·92553	26
35	20 53 24	9·95390	13 10 0	9·93595	4 1 10	9·92544	25
36	20 46 34	9·95358	13 1 26	9·93569	3 51 35	9·92536	24
37	20 39 42	9·95325	12 52 51	9·93544	3 42 0	9·92528	23
38	20 32 48	9·95292	12 44 14	9·93520	3 32 24	9·92520	22
39	20 25 53	9·95259	12 35 35	9·93495	3 22 48	9·92513	21
40	20 18 55	9·95227	12 26 56	9·93471	3 13 11	9·92507	20
41	20 11 56	9·95194	12 18 14	9·93447	3 3 34	9·92499	19
42	20 4 54	9·95162	12 9 32	9·93423	2 53 57	9·92493	18
43	19 57 51	9·95129	12 0 48	9·93399	2 44 19	9·92487	17
44	19 50 46	9·95097	11 52 3	9·93376	2 34 41	9·92481	16
45	19 43 39	9·95064	11 43 16	9·93353	2 25 2	9·92476	15
46	19 36 30	9·95032	11 34 28	9·93330	2 15 23	9·92471	14
47	19 29 19	9·95000	11 25 38	9·93307	2 5 44	9·92467	13
48	19 22 7	9·94968	11 16 49	9·93285	1 56 5	9·92462	12
49	19 14 52	9·94936	11 7 56	9·93262	1 46 25	9·92458	11
50	19 7 36	9·94904	10 59 2	9·93240	1 36 46	9·92455	10
51	19 0 17	9·94872	10 50 8	9·93219	1 27 6	9·92452	9
52	18 52 57	9·94840	10 41 12	9·93197	1 17 26	9·92449	8
53	18 45 35	9·94808	10 32 15	9·93176	1 7 45	9·92446	7
54	18 38 12	9·94777	10 23 17	9·93155	0 58 5	9·92444	6
55	18 30 46	9·94745	10 14 17	9·93135	0 48 24	9·92442	5
56	18 23 19	9·94714	10 5 17	9·93114	0 38 43	9·92440	4
57	18 15 49	9·94682	9 56 15	9·93094	0 29 3	9·92439	3
58	18 8 18	9·94651	9 47 11	9·93074	0 19 22	9·92438	2
59	18 0 45	9·94620	9 38 8	9·93055	0 9 41	9·92438	1
60	17 53 10	9·94589	9 29 2	9·93035	0 0 0	9·92438	0
Min.	N	Log. cos M	N	Log. cos M	N	Log. cos M	Min.
	8 h. and 20 h.		7 h. and 19 h.		6 h. and 18 h.		

PERSEUS ZONE, MAURITIUS. MEAN REFRACTIONS FOR DISTANCES.

Hour angle	*b–c*	*e–f*	*f–g*	*g–h*	*h–i*	*i–k*	*c–e*	*e–g*	*h–k*
h. m.									
21 0	8″194	3″222	6″733	7″163	3″475	7″706	14″207	9″781	11″421
15	6·662	2·462	5·300	5·640	2·685	6·297	11·410	7·609	9·112
30	5·553	1·940	4·280	4·558	2·126	5·276	9·389	6·076	7·441
45	4·724	1·561	3·523	3·758	1·721	4·496	7·876	4·942	6·176
22 0	4·085	1·287	2·946	3·141	1·423	3·898	6·714	4·081	5·223
15	3·574	1·083	2·497	2·660	1·196	3·413	5·790	3·430	4·463
30	3·163	0·932	2·140	2·286	1·024	3·026	5·050	2·925	3·859
45	2·824	0·821	1·854	1·982	0·894	2·701	4·444	2·521	3·366
23 0	2·540	0·740	1·620	1·731	0·794	2·433	3·943	2·207	2·964
15	2·297	0·684	1·428	1·530	0·721	2·206	3·516	1·956	2·634
30	2·088	0·665	1·270	1·361	0·668	2·009	3·150	1·766	2·355
45	1·906	0·634	1·138	1·227	0·634	1·826	2·841	1·618	2·104
0 0	1·747	0·636	1·032	1·115	0·617	1·679	2·568	1·505	1·913
15	1·604	0·656	0·946	1·027	0·616	1·548	2·329	1·433	1·750
30	1·474	0·693	0·878	0·961	0·633	1·417	2·123	1·399	1·604
45	1·358	0·749	0·828	0·913	0·667	1·309	1·942	1·403	1·495
1 0	1·252	0·831	0·798	0·889	0·720	1·212	1·785	1·447	1·413
15	1·152	0·938	0·788	0·887	0·798	1·122	1·651	1·537	1·338
30	1·063	1·078	0·789	0·913	0·904	1·039	1·541	1·686	1·334
45	0·979	1·264	0·792	0·971	1·048	0·966	1·458	1·903	1·349
2 0	0·903	1·509	0·924	1·073	1·242	0·901	1·402	2·213	1·411
15	0·836	1·832	1·054	1·233	1·501	0·848	1·394	2·657	1·536
30	0·778	2·272	1·254	1·471	1·857	0·807	1·441	3·276	1·755
45	0·737	2·873	1·560	1·828	2·349	0·787	1·573	4·152	2·101
3 0	0·719	3·738	2·030	2·380	3·057	0·783	1·838	5·448	2·649

PERSEUS ZONE, MAURITIUS. MEAN REFRACTIONS FOR POSITION ANGLES.

Hour angle	*b–c*	*e–f*	*f–g*	*g–h*	*h–i*	*i–k*	*c–e*	*e–g*	*h–k*
h. m.									
21 0	+1'29	−2'80	−1'89	−1'93	−2'69	+0'93	−0'29	−2'57	−1'27
15	0·71	2·11	1·67	1·68	2·09	0·46	0·50	2·09	1·20
30	+0·28	1·63	1·50	1·49	1·66	+0·13	0·66	1·75	1·15
45	−0·05	1·26	1·37	1·35	1·34	−0·14	0·77	1·48	1·11
22 0	0·30	0·98	1·27	1·24	1·09	0·34	0·86	1·28	1·08
15	0·51	0·76	1·19	1·15	0·89	0·51	0·93	1·11	1·05
30	0·68	0·58	1·12	1·07	0·73	0·64	0·99	0·98	1·03
45	0·83	0·43	1·06	1·01	0·60	0·76	1·04	0·86	1·01
23 0	0·96	0·30	1·00	0·95	0·48	0·86	1·08	0·76	0·99
15	1·07	0·18	0·91	0·89	0·37	0·98	1·11	0·67	0·97
30	1·17	−0·08	0·90	0·84	0·27	1·03	1·14	0·59	0·94
45	1·27	+0·01	0·85	0·79	0·18	1·11	1·17	0·50	0·92
0 0	1·36	0·11	0·80	0·73	−0·09	1·17	1·19	0·42	0·89
15	1·44	0·21	0·75	0·67	0·00	1·23	1·20	0·34	0·86
30	1·52	0·30	0·69	0·61	+0·09	1·29	1·21	0·25	0·82
45	1·59	0·40	0·62	0·54	0·19	1·34	1·21	0·16	0·78
1 0	1·66	0·51	0·55	0·46	0·30	1·38	1·21	−0·05	0·72
15	1·72	0·63	0·45	0·36	0·42	1·42	1·19	+0·07	0·66
30	1·78	0·77	0·33	0·24	0·57	1·45	1·15	0·22	0·57
45	1·83	0·94	−0·19	−0·09	0·74	1·47	1·10	0·40	0·45
2 0	1·88	1·15	+0·01	+0·10	0·95	1·47	1·02	0·62	0·30
15	1·88	1·41	0·26	0·35	1·22	1·46	0·89	0·90	−0·10
30	1·86	1·75	0·59	0·68	1·56	1·40	0·70	1·28	+0·18
45	1·78	2·20	1·07	1·15	2·03	1·28	−0·40	1·78	0·58
3 0	−1·61	+2·82	+1·75	+1·82	+2·67	−1·07	+0·05	+2·49	+1·18

PERSEUS ZONE, DUN ECHT. MEAN REFRACTIONS FOR DISTANCES.

Hour angle	*a–b*	*b–c*	*c–d*	*d–e*	*e–f*	*f–g*	*g–h*	*h–i*	*i–k*	*a–c*	*c–e*	*e–g*	*h–k*
h. m.	"	"	"	"	"	"	"	"	"	"	"	"	"
18 0	...	0·748	...	...	...	..	...	...	...	...	...	...	...
15	...	0·746	...	...	...	...	...	...	...	...	...	...	...
30	...	0·744	...	...	...	...	...	...	...	...	...	...	...
45	...	0·744	...	...	...	...	...	...	...	...	...	...	...
19 0	...	0·744	...	...	...	...	...	...	...	...	...	...	...
15	...	0·745	...	...	...	...	...	...	...	...	...	...	...
30	...	0·745	...	...	...	...	...	...	...	...	...	...	...
45	...	0·746	...	...	...	...	...	...	...	...	...	...	...
20 0	...	0·746	...	...	...	...	...	...	...	...	1·459	...	...
15	...	0·747	...	...	...	...	...	...	...	...	1·455	...	...
30	...	0·747	...	..	...	...	...	...	...	...	1·447	...	...
45	...	0·747	...	...	...	...	...	...	...	...	1·442	...	...
21 0	...	0·747	...	...	...	...	...	0·745	...	...	1·436	...	1·407
15	...	0·747	...	...	...	...	...	0·724	...	...	1·433	...	1·394
30	...	0·748	...	...	...	...	...	0·704	...	...	1·428	...	1·382
45	...	0·748	...	...	...	...	...	0·687	...	...	1·425	...	1·372
22 0	...	0·750	...	...	...	...	0·916	0·673	0·812	...	1·422	1·486	1·364
15	..	0·751	...	...	...	...	0·910	0·660	0·814	...	1·421	1·464	1·358
30	...	0·753	...	...	...	...	0·903	0·649	0·817	...	1·421	1·446	1·354
45	...	0·756	...	...	...	...	0·899	0·640	0·820	...	1·424	1·433	1·351
23 0	...	0·760	...	...	0·657	0·798	0·896	0·633	0·824	...	1·428	1·421	1·351
15	...	0·764	...	...	0·649	0·799	0·895	0·627	0·830	...	1·435	1·416	1·354
30	...	0·770	...	...	0·644	0·800	0·897	0·623	0·838	...	1·443	1·412	1·361
45	...	0·777	..	...	0·641	0·804	0·900	0·622	0·846	...	1·454	1·413	1·369
0 0	...	0·785	...	...	0·639	0·809	0·906	0·621	0·855	...	1·470	1·419	1·381
15	...	0·795	...	...	0·640	0·817	0·915	0·623	0·866	...	1·487	1·424	1·396
30	...	0·806	...	...	0·642	0·827	0·926	0·626	0·881	...	1·510	1·437	1·416
45	...	0·820	...	...	0·645	0·839	0·940	0·631	0·897	...	1·536	1·454	1·439
1 0	...	0·835	0·996	...	0·651	0·854	0·956	0·638	0·916	0·835	1·567	1·474	1·467
15	...	0·854	1·018	...	0·658	0·872	0·975	0·646	0·938	0·853	1·601	1·500	1·499
30	...	0·875	1·044	...	0·667	0·892	0·998	0·657	0·963	0·874	1·642	1·530	1·539
45	...	0·899	1·074	...	0·678	0·916	1·025	0·670	0·991	0·898	1·690	1·565	1·583
2 0	...	0·927	1·109	...	0·691	0·944	1·055	0·685	1·024	0·926	1·744	1·607	1·633
15	...	0·959	1·148	...	0·706	0·975	1·090	...	1·062	0·958	1·807	1·653	1·691
30	...	0·996	1·193	...	0·723	1·011	1·130	...	1·104	0·994	1·876	1·706	1·756
45	...	1·037	1·244	...	0·742	...	1·175	...	1·154	...	1·957	1·767	1·830
3 0	0·977	1·085	1·302	0·749	0·764	...	1·226	...	1·209	...	2·049	1·834	1·916
15	1·025	1·139	1·368	0·786	...	...	1·284	...	1·273	...	2·152	1·910	2·011
30	1·079	1·202	1·443	0·828	...	...	1·347	...	1·345	...	2·269	1·995	2·117
45	1·140	1·271	1·528	0·876	...	...	1·419	...	1·428	...	2·402	2·089	2·239
4 0	1·209	1·352	1·625	0·929	...	...	1·500	...	1·523	...	2·552	2·193	2·377
15	...	1·444	...	...	...	...	1·590	...	...	...	2·722	2·309	2·530
30	...	1·549	...	...	...	...	1·692	...	...	...	2·914	2·437	2·706
45	...	1·668	...	...	...	...	1·802	...	...	...	3·134	2·580	2·901
5 0	...	1·804	...	...	...	...	1·934	...	...	...	3·385	2·740	3·126
15	...	1·962	...	...	...	...	...	...	...	...	...	...	3·376
30	...	2·141	...	...	...	...	...	...	...	...	...	...	3·666
45	...	2·347	...	...	...	...	...	...	...	...	...	...	3·998
6 0	...	2·582	...	...	...	...	...	...	...	...	...	...	4·379

PERSEUS ZONE, DUN ECHT. MEAN REFRACTIONS FOR POSITION ANGLES.

Hour angle	*a–b*	*b–c*	*c–d*	*d–e*	*e–f*	*f–g*	*g–h*	*h–i*	*i–k*	*a–c*	*c–e*	*e–g*	*h–k*
h. m.	′	′	′	′	′	′	′	′	′	′	′	′	′
18 0	...	+0·64	...	...	...	...	...	...	...	...	...	...	...
15	...	0·66	...	...	...	...	...	...	...	...	...	...	...
30	...	0·66	...	...	...	...	...	...	...	...	...	...	...
45	...	0·65	...	...	...	...	...	...	...	...	...	...	...
19 0	...	0·63	...	...	...	...	...	...	...	...	...	...	...
15	...	0·60	...	...	...	...	...	...	...	...	...	...	...
30	...	0·58	...	...	...	...	...	...	...	...	...	...	...
45	...	0·54	...	...	...	...	...	...	...	...	...	...	...
20 0	...	0·51	...	...	...	...	...	...	...	...	+0·64	...	...
15	...	0·47	...	...	...	...	...	...	...	...	0·58	...	...
30	...	0·44	...	...	...	...	...	...	...	...	0·53	...	...
45	...	0·40	...	...	...	...	...	...	...	...	0·48	...	...
21 0	...	0·36	...	...	...	...	...	+0·58	...	...	0·43	...	+0·48
15	...	0·33	...	...	...	...	...	0·53	...	...	0·38	...	0·43
30	...	0·29	...	...	...	...	...	0·46	...	...	0·34	...	0·37
45	...	0·25	...	...	...	...	...	0·40	...	...	0·29	...	0·32
22 0	...	0·21	...	...	...	...	+0·30	0·35	+0·20	...	0·25	+0·33	0·28
15	...	0·18	...	...	...	...	0·26	0·30	0·16	...	0·21	0·28	0·23
30	...	0·14	...	...	...	...	0·21	0·25	0·13	...	0·17	0·24	0·19
45	...	0·11	..	...	...	...	0·17	0·21	0·10	...	0·13	0·19	0·15
23 0	...	0·08	...	...	+0·17	+0·12	0·12	0·16	0·06	...	0·09	0·15	0·11
15	...	0·04	...	...	0·13	0·08	0·08	0·12	+0·03	...	0·06	0·10	0·07
30	...	+0·01	...	...	0·09	+0·04	0·04	0·08	0·00	...	+0·02	0·06	+0·03
45	...	−0·02	...	...	0·05	0·00	+0·01	+0·03	−0·03	...	−0·02	+0·02	−0·01
0 0	...	0·05	...	...	+0·01	−0·04	−0·04	−0·01	0·06	...	0·05	−0·02	0·05
15	...	0·08	...	...	−0·04	0·07	0·07	0·05	0·09	...	0·08	0·06	0·08
30	...	0·11	...	...	0·08	0·11	0·11	0·09	0·12	...	0·12	0·10	0·12
45	...	0·14	...	...	0·12	0·15	0·15	0·13	0·15	...	0·15	0·14	0·15
1 0	...	0·16	−0·18	...	0·16	0·19	0·19	0·17	0·17	−0·16	0·18	0·18	0·19
15	...	0·19	0·21	...	0·21	0·23	0·23	0·22	0·20	0·19	0·21	0·22	0·23
30	...	0·22	0·24	...	0·25	0·27	0·27	0·26	0·23	0·22	0·25	0·27	0·26
45	...	0·25	0·27	...	0·30	0·31	0·31	0·31	0·26	0·25	0·28	0·31	0·30
2 0	...	0·27	0·30	...	0·35	0·35	0·35	−0·35	0·28	0·27	0·31	0·36	0·34
15	...	0·30	0·33	...	0·40	0·39	0·40	...	0·31	0·30	0·35	0·41	0·38
30	...	0·33	0·37	...	0·46	−0·44	0·45	...	0·34	−0·33	0·39	0·46	0·43
45	...	0·36	0·40	...	0·52	..	0·50	...	0·37	...	0·42	0·52	0·47
3 0	−0·46	0·39	0·44	−0·49	−0·58	...	0·55	...	0·40	...	0·46	0·58	0·52
15	0·50	0·42	0·48	0·54	...	...	0·61	...	0·44	...	0·51	0·64	0·58
30	0·55	0·45	0·52	0·60	...	...	0·68	...	0·47	...	0·55	0·71	0·64
45	0·61	0·49	0·57	0·66	...	...	0·75	..	0·51	..	0·60	0·79	0·70
4 0	−0·66	0·52	−0·62	−0·72	...	...	0·83	...	−0·55	...	0·66	0·88	0·78
15	...	0·56	...	...	...	...	0·91	...	...	...	0·72	0·97	0·86
30	...	0·61	...	...	...	...	1·01	...	...	...	0·79	1·08	0·95
45	...	0·66	...	...	...	...	1·12	...	...	...	0·87	1·19	1·05
5 0	...	0·72	...	...	...	...	−1·25	...	...	...	−0·96	−1·33	1·16
15	...	0·79	...	...	...	...	...	...	...	...	...	...	1·30
30	...	0·87	...	...	...	...	...	...	...	...	...	...	1·45
45	...	0·96	...	...	...	...	...	...	...	...	...	...	1·63
6 0	.	−1·07	...	...	...	...	...	...	...	...	...	...	−1·83

NORTH ZONE, DUN ECHT. MEAN REFRACTIONS FOR DISTANCES.

Hour angle	*a–b*	*b–c*	*c–d*	*d–e*
h. m.				
21 0	0″·513	0″·623	0″·756	0″·551
15	·501	·610	·741	·542
30	·490	·597	·727	·532
45	·480	·584	·712	·522
22 0	·470	·572	·697	·512
15	·462	·562	·683	·501
30	·454	·552	·668	·491
45	·446	·544	·655	·481
23 0	·441	·538	·642	·471
15	·437	·534	·630	·461
30	·434	·530	·620	·453
45	·433	·529	·612	·446
0 0	·432	·529	·605	·439
15	·434	·532	·599	·433
30	·436	·535	·596	·430
45	·440	·541	·595	·427
1 0	·445	·548	·595	·425
15	·452	·556	·598	·425
30	·460	·566	·601	·426
45	·469	·577	·607	·429
2 0	·478	·589	·615	·433
15	·489	·602	·625	·439
30	·499	·615	·637	·445
45	·511	·629	·650	·453
3 0	0″·522	0″·643	0″·664	0″·462

CHAPTER V.

THE OBSERVATIONS AT MAURITIUS.

It was intended that the observations of Juno should commence on October 10, and the necessary stars of comparison were selected; and the right ascension and declination of the middle point between star and planet, as well as the position angle and distance of the star of comparison from the planet, were computed and published ('Monthly Notices,' vol. xxxiv. pp. 296–300) for each evening and morning between that date and November 30.

Unfortunately Lord Lindsay's yacht 'Venus,' with the instruments, did not reach Port Louis till November 2, and it was November 5 before the heliometer could be unpacked at Belmont.

On the 7th the instrument was completely erected, and adjusted by the sun and stars in daylight, and the adjustments, though tested frequently afterwards, were not again touched till the instrument was dismounted.

The weather, which during September and October had been superb, became cloudy, and nothing could be done on the evenings of the 7th and 8th. On the 9th Juno was found at once, with the small stars (9th magnitude) ϵ and δ in the field, and there was just time to see that on favourable occasions 9th-magnitude stars could be measured with the heliometer, when clouds intervened and stopped observation.

The first observations were secured on the night of the 10th, but under circumstances so unfavourable as to be worthless.

The first series of observations of value was made on November 12, and observations were secured altogether on twelve evenings and eleven mornings between that date and November 30.

Many of these observations are by no means so complete as desirable, but the reader will be better able to form an opinion on this point from the observations themselves and the notes attached to them.

Juno being past opposition (opposition was on November 5), the object was to secure measures as soon as possible after sunset.

Accordingly at sundown, the scales of the segments having been set at the computed distance, the position circle to the computed position angle, and the axis of the tube directed by the circles to the declination and hour angle of the middle point between the star and planet, the driving clock was set going, and a lookout kept at short intervals for the planet and star of comparison. Before this (and sometimes after the observations) the sidereal chronometer used during the observations was compared with the normal sidereal chronometer, whose errors were determined every night by Dr. Copeland's observations of transits of stars in the meridian.

The comparisons were made by estimation to the nearest $0^s.1$, an accuracy amply sufficient,

as on no occasion does the change of distance between star and planet exceed 0″·01 in a second of time. These comparisons and the resulting corrections will be found at pp. 145 and 146.

The barometer and thermometer were recorded, generally for each complete measure.

These readings are tabulated at the bottom of each page.

The barometer (an aneroid) and the thermometer were placed in a ventilated box attached to a pillar accessible from the observatory; thus no time was lost in making the records.

All the records of barometer, thermometer, chronometer comparisons, and the observations themselves were entered in the same book, previously ruled and prepared for the purpose, of which the following page is a facsimile.

The chronometer comparisons, and some measures of double stars, &c., are entered on the back of these sheets in the original book.

All the records during the Juno series were entered by the observer (Mr. Gill) himself, to avoid as far as possible errors of a clerk.

For this purpose a table conveniently placed carried the observing book and the chronometer, and the observer was provided with several flat boxes, which could be placed so as to form a platform of easily regulated height, upon which he could stand and command the eye-piece comfortably.

The easy position of the observer's head, when standing and observing objects at altitudes of 30° or 40°, tends much to promote accuracy in the measures.

One of the crew of the yacht assisted. His duty was to turn the observatory as required, and to throw light from a bull's-eye lantern upon the white papier-mâché reflector λ (to illuminate the scales when required), or upon the proper reflectors, to read the indications of the position circle.

As soon as the planet and star of comparison were visible, observations were commenced.

First a position angle was observed in the manner already described.

The observer could hear distinctly the beats of the chronometer, so that the instant he estimated the true symmetrical passing of the images he began to count 1, 2, 3, 4, &c.; turned to the chronometer, continued counting till 10; and then noted down the seconds from the chronometer face, less 10ˢ, and afterwards the minute and hour. Then the indication of the most convenient vernier was noted, and thus a measure of position angle was completed.

The instant of a 'symmetrical passing' in a measure of distance was then noted in a precisely similar manner, and then the scale read off.

The form was prepared to save writing.

In space 1 is entered the reading of the *decimals* of the micrometer head when bisecting the division adjacent to the pointer on the farther side from the micrometer head (that is to say, the higher-numbered division of the two divisions adjacent to the pointer); in space 2, the smaller-numbered of the two divisions next the pointer; in space 3, the whole number of revolutions (0 or 1) which that division is distant from the pointer; in space 4, the reading of the decimals of the head when the latter division is bisected.

Thus the original entry—

A	1555	131	0	1560
B	1448	15	1	1452

LORD LINDSAY'S MAURITIUS EXPEDITION, 1874.

OPPOSITION OF JUNO. HELIOMETER OBSERVATIONS.

STAR OF COMPARISON { Posn. Angle_____ / Reading of Scale A _____ } Date of_____, 1874

CHRONOMETER, No._____

h.	m.	s.

will mean, when translated into the notation afterwards adopted as more convenient for computing—

	Preceding Division.		Following Division.	
	Division.	Screw.	Division.	Screw.
Scale *A* . . .	132	0·555	131	2·560
Scale *B* . . .	16	1·448	15	3·452

Each page of the form contains a complete group, according to the definition given on p. 64.

It must be noted that the form is not quite complete, and that an additional position-angle measure is required, but this was made and entered in the form below the central position-angle.

Such a group, with its eight observations, scale readings, &c., occupied on the average a little over twenty minutes.

The actual averages, grouped by ten, are in minutes—

20·9 21·8 24·2 23·5 23·2 21·0 23·6.

In every case the average is much increased by interruptions from cloud.

On fine occasions the group is measured in fifteen minutes.

The actual times vary from fourteen minutes as a minimum to forty-five minutes as a maximum; but, allowing for average interruption, twenty-three minutes may be looked upon as a safe basis upon which any future series of observations may be arranged.

When the weather permitted, four groups were observed, according to the plan of observation.[1]

These four groups having been secured, the observer went to bed. If the groups were secured with too great fatigue and delay, a double star was measured as a check upon the last distance of optical centres of the lenses, and a few measures of the focal point were made by focussing on double stars.

The sailor on duty had orders to have lamps ready, and to call the observer at a fixed hour, corresponding to the time when the planet had about $2\frac{1}{2}$ hours' hour angle W., so that observations might begin before hour angle 3^h W.

Whatever the character of the weather, watch was kept till within an hour of sunrise, and often observations were thus obtained after what promised to be a hopeless watch. Observations once commenced were pursued till cloud or daylight prevented their further continuance. In a tropical country such watching is not accompanied with the feeling of chill and misery which attends a long watch during a raw, cloudy, and fruitless night at home. The temperature

[1] A complete comparison of the planet with two stars *a* and *b* should involve—

(1) A group of comparisons with *b*;
(2) A group of comparisons with *a*;
(3) Reverse position circle and compare again with *a*;
(4) A group of comparisons with *b*.

Such a comparison is symmetrical and complete, and in such an investigation it is necessary to employ in the computations only complete comparisons of this sort.

It is unfortunate that in the present series there are only three comparisons of this sort of evening observations and a similar number of morning observations.

The whole series had been arranged with the intention of trying various methods, and especially to test whether it might be better, when suitable stars were available, to use one star very near the planet or two opposite stars at a considerable distance from the planet, and also to test whether position angles might be taken into account in parallax determinations. It so happened, that on the best observing nights, only one star of comparison had been selected, and thus, in the limited series that it was possible to secure, justice was not done to the method of two stars, which seems to be undoubtedly the best.

at Belmont was then most pleasant, and a cricketing suit of thin flannel, with a warm scarf round the loins, was the most comfortable and suitable dress.

If the observer had no other duty to attend to, and could rest during the day, such work could be continued with ease and comfort for any reasonable period; but at this time the other instruments were being mounted and adjusted, and the observer was constantly occupied in these matters during the day, so that it must be admitted towards the end of the series the feeling of fatigue was oppressive, and the morning summons became a trial of resolution.

The observations so made will be found at pp. 106–116. They are entered exactly as computed, and the errors of reading, or every reading adopted different from the original, noted in the column of remarks. The volume of original observations (lettered 'Juno Heliometer Observations,' vol. i.) is deposited along with the other original observations of the expedition.

As soon as the Juno series was finished, observations were commenced on two zones of stars for determining the value of the scale, and these, with some measures of stars for the zero of position circle (according to the programme of Auwers and Winnecke), and some measures of double stars, were continued, with a few interruptions for personal equation determination, &c., till December 26, when it became necessary to discontinue them in order to complete some necessary longitude and latitude determinations and the preparations for the chronometer expedition homewards. These star observations will be found at pp. 86–94, and are originally recorded at the end of the 'Juno Observations,' and at the beginning of a similar volume marked 'Juno Heliometer Observations,' vol. ii.

The observations of the sun's diameter made with the heliometer in the beginning of December, part of which are entered in the same original volumes, do not enter into the present discussion, and will be discussed along with the transit of Venus observations.

CHAPTER VI.

TABLE I.

STAR OBSERVATIONS.

Group — Date — Objects	Position Angles: Rotation number	Time by chronometer	Position circle: Vernier I.	Position circle: II.	Mean	Distances: Rotation number	Time by chronometer	Scale A: Preceding div. Scale	Scale A: Preceding div. Screw	Scale A: Following div. Scale	Scale A: Following div. Screw	Scale B: Preceding div. Scale	Scale B: Preceding div. Screw	Scale B: Following div. Scale	Scale B: Following div. Screw	Resulting value, Scale A – Scale B corrected for screw and division error
		h. m. s.	° ′	′	° ′		h. m. s.									
I. Nov. 13, 1874 *a* Piscium	1 bis	0 30 0	136 25	...	136 25·0	1	0 30 0	75	0·736	74	2·722	74	0·865	73	2·880	+ 1·8776
	2 „	0 35 0	143 43	...	143 43·0	2	0 35 0	75	0·522	74	2·520	74	1·123	73	3·132	+ 1·4130
	3* „	0 40 0	327 20	...	327 20·0	3	0 40 0	75	0·311	74	2·313	74	0·932	73	2·957	+ 1·3943
	4 „	0 45 0	317 13	...	317 13·0	4	0 45 0	75	0·570	74	2·579	74	0·713	73	2·714	+ 1·8823
II. Nov. 21, 1874 *a* Piscium	5 bis	Not recorded	321	20	321 20·0	5	Not recorded	75	0·404	74	2·396	74	0·778	73	2·787	+ 1·6414
	6 „		321	59·5	321 59·5	6		75	0·640	74	2·644	74	0·537	73	2·540	+ 2·1253
	7 „		...	...	...	7		75	0·906	74	2·908	74	0·791	73	2·789	+ 2·1405
	8 „		141	28·5	141 28·5	8		75	0·665	74	2·669	74	1·036	73	3·046	+ 1·6452
III. Nov. 23, 1874 ζ Piscium	9* bis	1 20 0	245 16·5	...	245 16·5	9	1 20 0	75	0·842	74	2·866	74	0·532	73	2·528	+ 2·3470
	10 „	1 25 0	242 5·5	...	242 5·5	10	1 25 0	75	0·396	74	2·404	74	0·010	73	2·016	+ 1·4104
	11* „	1 30 0	242 4·0	...	242 4·0	11	1 30 0	75	0·400	74	2·397	74	0·000	73	2·992	+ 1·4262
	12 „	1 35 0	244 40·0	...	244 40·0	12	1 35 0	75	0·840	74	2·850	74	0·520	73	2·532	+ 2·3419
IV. Nov. 23, 1874 ζ Piscium	13* bis	1 45 0	244 14	...	244 14·0	13	1 45 0	75	0·843	74	2·863	74	0·532	73	2·545	+ 2·3390
	14 „	1 50 0	242 16	...	242 16·0	14	1 50 0	75	0·430	74	2·445	74	1·040	73	3·023	+ 1·4288
	15 „	1 55 0	243 35	...	243 35·0	15	1 55 0	75	0·410	74	2·419	74	1·035	73	3·016	+ 1·4123
	16 „	2 0 0	242 50	...	242 50·0	16	2 0 0	75	0·935	74	2·937	74	0·585	73	2·585	+ 2·3764
V. Nov. 29, 1874 Castor	17 bis	Not recorded	230 7·5	...	230 7·5	17	Not recorded	75	0·192	74	2·218	74	0·812	73	2·828	+ 1·4160
	18 „		244 42·5	...	244 42·5	18*		75	0·710	74	2·740	74	0·439	73	2·459	+ 2·2951
	19* „		62 54·5	...	62 54·5	19		75	0·868	74	2·870	74	0·575	73	2·590	+ 2·3067
	20 „		50 20·5	...	50 20·5	20*		75	0·457	74	2·461	74	1·062	73	3·083	+ 1·4104
VI. Dec. 1, 1874 τ^6 & τ^7 Eridani	21	0 20 30	343 56·00	55·5	343 55·75	22	0 23 38	98	1·299	97	2·307	50	1·852	49	3·820	+95·4869
	24	0 31 26	343 51·75	52·0	343 51·88	23	0 27 54	51	1·846	50	3·845	97	1·650	96	3·664	−91·7898
	...	...	...	...	...	25	0 34 0	51	1·852	50	3·856	97	1·870	96	3·880	−91·9997
	27	0 43 33	343 55·75	55·5	343 55·63	26	0 37 15	98	1·309	97	3·312	50	1·844	49	3·838	+95·4906
VII. Dec. 1, 1874 τ^6 & τ^7 Eridani	28	0 47 14	163 54·75	55·0	163 54·88	29	0 49 0	98	1·213	97	3·225	50	1·750	49	3·747	+95·4948
	31	1 7 38	163 52·0	51·75	163 51·88	30	0 53 10	51	1·760	50	3·767	97	1·570	96	3·583	−91·7943
	...	...	...	...	...	32	1 10 13	51	1·755	50	3·755	97	1·550	96	3·570	−91·7863
	34	1 15 27	163 54·75	55·0	163 54·88	33	1 14 55	98	1·238	97	3·248	50	1·774	49	3·763	+95·4985
VIII. Dec. 1, 1874 ξ^1 & ξ^2 Can. Maj.	35	2 37 33	237 38·5	37·5	237 38·00	36	2 39 26	105	1·000	104	3·008	44	0·425	43	2·432	+122·6001
	38	2 44 59	237 35·75	35·5	237 35·63	37	2 42 0	45	0·470	44	2·480	104	1·354	103	3·369	−118·8686
	...	...	...	...	...	39	2 46 26	45	0·485	44	2·491	104	1·380	103	3·381	−118·8744
	41	2 52 3	237 38·5	38·0	237 38·25	40	2 49 37	105	0·986	104	2·991	44	0·432	43	2·449	+122·5725

3, 11. Time by chronometer is interpolated. 9. Tube preceding. Half distance measured thus—*a* α *b* β. 13. Tube following.
18. Scale B.; preceding div. of scale altered from 73. 19. Air very unsteady. 20. Scale A.; preceding div. of scale altered from 74.

Group	Chron. corr.	Bar.	Ther.	Group	Chron. corr.	Bar.	Ther.
	m. s.	in.	°		m. s.	in.	°
I.	...	...	...	V.	...	...	...
II.	...	...	...	VI.	+1 41	30·02	73·5
III.	...	...	...	VII.	+1 41	30·02	73·5
IV.	...	...	...	VIII.	+1 41	30·02	73·5

Group — Date — Objects	Position Angles					Distances									
			Position circle					Scale A				Scale B				Resulting value, Scale A − Scale B corrected for screw and division error
	Rotation number	Time by chronometer	Vernier I.	II.	Mean	Rotation number	Time by chronometer	Preceding div.		Following div.		Preceding div.		Following div.		
								Scale	Screw	Scale	Screw	Scale	Screw	Scale	Screw	
		h. m. s.	° ′	′	° ′ ″		h. m. s.									
IX.	42	2 55 40	57 37·5	38·25	57 37·88	43*	2 56 47	105	0·492	104	2·508	43	1·940	42	3·940	+ 122·5852
Dec. 1, 1874	45	3 2 51	57 35·25	35·75	57 35·50	44	3 1 10	44	1·998	43	3·984	104	0·873	103	2·863	− 118·8603
ξ^1 & ξ^2 Can. Maj.	...	...	...	...	...	46	3 4 20	44	1·978	43	3·986	104	0·891	103	2·878	− 118·8863
	48	3 9 1	57 37·25	37·5	57 37·38	47	3 6 42	105	0·491	104	2·491	43	1·921	42	3·930	+ 122·5911
X.	49	3 28 15	309 22·75	20·25	309 21·50	50	3 29 34	98	1·470	97	3·485	50	1·988	49	3·979	+ 95·5067
Dec. 1, 1874	52	3 33 43	309 19·75	19·00	309 19·38	51	3 32 1	51	1·972	50	3·982	97	1·832	96	3·835	− 91·8411
P. A. stars,	...	...	...	...	...	53	3 35 8	51	1·980	50	3·992	97	1·832	96	3·833	− 91·8309
γ & δ	55	3 41 0	309 22·00	21·5	309 21·75	54	3 37 30	98	1·477	97	3·484	50	1·990	49	3·975	+ 95·5106
XI.	56	3 43 21	129 22·0	22·0	129 22·00	57	3 46 5	98	1·107	97	3·099	50	1·570	49	3·574	+ 95·5534
Dec. 1, 1874	59	3 52 46	129 18·5	18·5	129 18·5	58	3 49 45	51	1·596	50	3·586	97	1·435	96	3·439	− 91·8252
P. A. stars,	...	...	...	...	...	60	3 56 25	51	1·583	50	3·585	97	1·419	96	3·420	− 91·8147
γ & δ	62	4 3 28	129 22·0	22·25	129 22·13	61	3 59 7	98	1·103	97	3·107	50	1·598	49	3·580	+ 95·5386
XII.	63* bis		204 39·5	39·0	204 39·25	63		75	0·611	74	2·634	74	0·632	73	2·640	+ 2·0091
Dec. 1, 1874	64 „	Not recorded	...	...	...	64	Not recorded	75	0·375	74	2·374	74	0·664	73	2·683	+ 1·7254
Δ 23	65 „		345 37·0	37·0	345 37·00	65		75	0·763	74	2·742	74	1·070	73	3·068	+ 1·7024
	66 „		32 45·0	46·0	32 45·50	66		75	0·789	74	2·804	74	0·820	73	2·825	+ 1·9963
XIII.	67	1 21 53	48 24·0	24·0	48 24·00	68	1 23 40	103	0·492	102	2·501	45	1·870	44	3·851	+ 114·6578
Dec. 2, 1874	70	1 30 53	48 21·5	21·5	48 21·50	69	1 27 4	46	1·884	45	3·874	102	0·874	101	2·880	− 110·9775
Perseus zone,	...	...	...	...	...	71	1 32 34	46	1·900	45	3·890	102	0·901	101	2·893	− 110·9817
i–k	73	1 37 57	48 25·0	25·0	48 25·00	72	1 35 44	103	0·504	102	2·490	45	1·865	44	3·866	+ 114·6530
XIV.	74	1 39 49	228 25·0	25·0	228 25·00	75	1 42 1	103	1·060	102	3·059	46	0·420	45	2·405	+ 114·6699
Dec. 2, 1874	77	1 46 42	228 22·5	22·0	228 22·25	76	1 44 33	47	0·458	46	2·465	102	1·442	101	3·429	− 110·9546
Perseus zone,	...	...	...	...	...	78	1 49 13	47	0·449	46	2·440	102	1·410	101	3·405	− 110·9435
i–k	80	1 54 12	228 24·5	24·5	228 24·50	79	1 51 35	103	1·044	102	3·044	46	0·377	45	2·395	+ 114·6806
XV.	81	2 7 48	267 51·0	50·0	267 50·50	82	2 11 0	96	1·756	95	3·742	52	1·420	51	3·430	+ 88·3468
Dec. 2, 1874	84	2 16 26	267 46·0	45·5	267 45·75	83	2 13 50	53	1·405	52	3·406	96	0·075	95	2·065	− 84·6408
Perseus zone,	...	...	...	...	...	85	2 18 45	53	1·388	52	3·389	96	0·068	95	2·060	− 84·6515
h–i	87	2 27 21	267 51·0	50·5	267 50·75	86	2 22 22	96	1·742	95	3·742	52	1·425	51	3·423	+ 88·3408
XVI.	88*	23 58 20	251 33·0	33·5	251 33·25	89	3 24 10	106	0·979	105	2·986	43	0·488	42	2·489	+ 126·5232
Dec. 3, 1874	91	3 30 25	251 30·0	29·5	251 29·75	90	3 27 11	44	0·543	43	2·540	105	1·390	104	3·390	− 122·8350
Perseus zone,	...	...	...	...	...	92	3 35 32	44	0·523	43	2·514	105	1·392	104	3·405	− 122·8663
g–h	94	3 41 53	251 33·0	32·5	251 32·75	93	3 39 8	106	1·000	105	3·000	43	0·455	42	2·454	+ 126·5749

43. Scale A; following div. of screw altered from 0·508.
63. Time by chronometer must be about 4 h. 30 m. S. T.
88. The chronometer (43) sidereal used. After that M. T. chronometer 31. (31) 6 h. 18 m. 14 sec. = (43) 2 h. 59 m. 20 sec.

Group	Chron. corr.	Bar.	Ther.	Group	Chron. corr.	Bar.	Ther.
	m. s.	in.	°		m. s.	in.	°
IX.	+ 1 41	30·02	73·5	XIII.	...	30·00	73·8
X.	+ 1 41	30·02	73·5	XIV.	...	30·00	73·8
XI.	+ 1 41	30·02	73·5	XV.	...	30·00	73·8
XII.	+ 1 41	...	...	XVI.	...	30·02	73·9

Group — Date — Objects	Position Angles					Distances									Resulting value, Scale A − Scale B corrected for screw and division error
								Scale A				Scale B			
			Position circle					Preceding div.		Following div.		Preceding div.		Following div.	
	Rotation number	Time by chronometer	Vernier I.	II.	Mean	Rotation number	Time by chronometer	Scale	Screw	Scale	Screw	Scale	Screw	Scale	Screw	
		h. m. s.	° ′	′	° ′		h. m. s.								
XVII.	95*	3 49 38	71 32·5	32·5	71 32·50	96	3 46 33	106	0·158	105	2·150	42	1·891	41	3·890	...
Dec. 3, 1874	98	3 53 34	71 30·0	30·0	71 30·00	97	3 51 13	43	1·963	42	3·966	105	0·866	104	2·864	− 122·8873
Perseus zone, *g–h*	...	...	...	...	...	99	3 55 34	43	1·962	42	3·961	105	0·873	104	2·876	− 122·9000
	101	4 3 13	71 32·0	31·5	71 31·75	100	4 0 47	106	0·483	105	2·500	42	1·910	41	3·907	+ 126·6136
XVIII.	102	4 9 2	70 11·5	11·0	70 11·25	103	4 10 43	102	1·719	101	3·729	46	0·756	45	2·759	+ 112·9886
Dec. 3, 1874	105	4 19 21	70 10·0	9·5	70 9·75	104	4 16 11	47	0·790	46	2·782	102	0·105	101	2·110	− 109·3080
Perseus zone, *f–g*	...	...	...	...	...	106	4 21 6	47	0·788	46	2·795	102	0·102	101	2·110	− 109·3009
	108	4 25 52	70 11.5	11·5	70 11·50	107	4 23 31	102	1·735	101	3·735	46	0·741	45	2·751	+ 113·0109
XIX.	109	4 29 30	250 11·5	11·0	250 11·25	110	4 33 18	103	0·214	102	2·204	46	1·191	45	3·205	+ 113·0321
Dec. 3, 1874	112	4 38 47	250 9·0	9·0	250 9·00	111	4 36 53	47	1·240	46	3·257	102	0·579	101	2·575	− 109·3074
Perseus zone, *f–g*	...	...	...	...	...	113	4 40 21	47	1·250	46	3·224	102	0·564	101	2·569	− 109·3082
	115	4 47 11	250 11·5	11·0	250 11·25	114	4 43 58	103	0·214	102	2·213	46	1·196	45	3·205	+ 113·0340
XX.	116	4 56 55	272 32·5	32·5	272 32·50	117	4 58 51	97	1·050	96	3·045	52	0·210	51	2·220	+ 90·8542
Dec. 3, 1874	119	5 5 11	272 30·5	30·0	272 30·25	118	5 2 13	53	0·199	52	2·202	96	1·370	95	3·359	− 87·1374
Perseus zone, *e–f*	...	...	...	...	...	120	5 6 44	53	0·213	52	2·212	96	1·375	95	3·370	− 87.1325
	122	5 13 10	272 32·5	32·0	272 32·25	121	5 10 13	97	1·060	96	3·050	52	0·195	51	2·196	+ 90·8811
XXI.	123	5 25 53	92 32·0	32·5	92 32·25	124	5 27 45	97	0·920	96	2·922	52	0·070	51	2·075	+ 90·8675
Dec. 3, 1874	126	5 42 13	92 31·5	31·0	92 31·25	125	5 34 25	53	0·075	52	2·075	96	1·268	95	3·267	− 87·1671
Perseus zone, *e–f*	...	...	...	...	...	127	6 0 2	53	0·110	52	2·110	96	1·318	95	3·300	− 87·1727
	129	6 6 21	92 35·0	34·5	92 34·75	128	6 2 54	97	0·995	96	2·990	52	0·122	51	2·130	+ 90·8870
XXII.	130	5 36 8	163 57·0	57·5	163 57·25											
Dec. 4, 1874	131	5 39 28	163 50·5	50·5	163 50·50											
τ^6 & τ^7 Eridani	132	5 44 35	343 50·5	50·5	343 50·50											
	133	5 47 00	343 57·0	57·0	343 57·00											
XXIII.	135 bis	5 55 29	57 39·5	40·0	57 39·75											
Dec. 4, 1874	136 „	5 57 41	57 34·25	34·5	57 34·38											
ξ & ξ^2 Can. Maj.	137 „	5 59 55	237 34·0	34·25	237 34·13											
	138 „	6 2 26	237 39·5	39·5	237 39·50											
XXIV.	134	6 15 20	309 27·0	26·5	309 26·75											
Dec. 4, 1874	135	6 17 23	309 19·0	18·5	309 18·75											
P. A. stars, γ & δ	136	6 19 32	129 19·0	19·0	129 19·00											
	137	6 23 0	129 25·0	25·0	129 25·00											

95. Bad observations in distance.

Group	Chron. corr.	Bar.	Ther.	Group	Chron. corr.	Bar.	Ther.
	m. s.	in.	°		m. s.	in.	°
XVII.	...	30·02	73·9	XXI.	...	30·02	73·7
XVIII.	...	30·02	73·8	XXII.	+ 1 50	30·01	74·0
XIX.	...	30·02	73·8	XXIII.	+ 1 50	30·01	74·0
XX.	...	30·02	73·7	XXIV.	+ 1 50	30·01	73·8

Group — Date — Objects	Position Angles					Distances									
	Rotation number	Time by chronometer	Position circle		Mean	Rotation number	Time by chronometer	Scale A				Scale B				Resulting value, Scale A − Scale B corrected for screw and division error
			Vernier I.	II.				Preceding div.		Following div.		Preceding div.		Following div.		
								Scale	Screw	Scale	Screw	Scale	Screw	Scale	Screw	
		h. m. s.	° ′	′	° ′		h. m. s.									
XXV. Dec. 4, 1874 *a* Piscium	138 bis	7 10 30	123 23·5	...	123 23·5	138	7 10 30	75	0·308	74	2·313	74	0·723	73	2·710	+ 1·6214
	139 „	7 14 27	158 54·5	...	158 54·5	139	7 14 27	75	0·564	74	2·580	74	0·510	73	2·509	+ 2·0871
	140 „	7 18 25	340 37·0	...	340 37·0	140*	7 18 25	75	0·955	74	2·960	74	0·840	73	2·840	+ 2·1422
	141 „	7 22 15	306 53·0	...	306 53·0	141	7 22 15	75	0·759	74	2·755	74	1·141	73	3·145	+ 1·6320
XXVI. Dec. 6, 1874 τ^6 & τ^7 Eridani	142	0 52 54	163 57·0	57·5	163 57·25	143	0 54 31	98	1·262	97	3·282	50	1·769	49	3·774	+ 95·5247
	145	1 0 47	163 50·0	50·5	163 50·25	144	0 58 54	51	1·783	50	3·793	97	1·628	96	3·645	− 91·8291
	146*a*	1 2 7	163 50·0	50·5	163 50·25	146	1 3 32	51	1·785	50	3·773	97	1·605	96	3·629	− 91·8188
	148	1 8 19	163 56·5	57·5	163 57·00	147	1 5 52·5	98	1·290	97	3·308	50	1·805	49	3·788	+ 95·5260
XXVII. Dec. 6, 1874 τ^6 & τ^7 Eridani	149	1 11 15	343 57·5	57·5	343 57·50	150	1 12 51	98	1·375	97	3·376	50	1·874	49	3·875	+ 95·5216
	152	1 20 52	343 49·5	50·0	343 49·75	151	1 16 35	51	1·865	50	3·855	97	1·684	96	3·690	− 91·8056
	153	1 22 28	343 50·0	50·0	343 50·00	154	1 23 36	51	1·850	50	3·855	97	1·700	96	3·699	− 91·8256
	156	1 28 30	343 57·5	57·5	343 57·50	155	1 26 2	98	1·370	97	3·375	50	1·881	49	3·875	+ 95·5152
XXVIII. Dec. 6. 1874 ξ^1 & ξ^2 Can. Maj.	157	1 34 57	57 38·0	39·0	57 38·50	158	1 33 19	105	0·376	104	2·388	43	1·887	42	3·900	+ 122·5224
	160	1 44 22	57 33·0	34·0	57 33·50	159	1 40 37	44	1·930	43	3·930	104	0·760	103	2·760	− 118·8160
	161	1 46 52	57 33·0	34·0	57 33·50	162	1 48 52	44	1·920	43	3·912	104	0·764	103	2·787	− 118·8458
	164	1 53 39	57 38·5	39·5	57 39·00	163	1 51 37	105	0·382	104	2·398	43	1·900	42	3·903	+ 122·5223
XXIX. Dec. 6, 1874 ξ^1 & ξ^2 Can. Maj.	165	2 0 53	237 38·5	39·0	237 38·75	165	Distance was not observed in this group									
	166	2 5 14	237 34·5	34·5	237 34·50	166										
	167	2 8 16	237 34·0	34·0	237 34·00	167										
	167*a*	2 10 1	237 39·5	39·0	237 39·25	167*a*										
XXX. Dec. 6, 1874 P. A. stars, γ & δ	168	2 15 28	129 31·0	31·5	129 31·25	168	Distance was not observed in this group									
	169	2 17 45	129 23·5	23·5	129 23·50	169										
	170	2 19 54	129 23·0	23·5	129 23·25	170										
	170*a* bis	2 21 59	129 31·0	30·5	129 30·75	170*a* bis										
XXXI. Dec. 6, 1874 P. A. stars, γ & δ	171	2 24 40	309 30·0	29·5	309 29·75	171	Distance was not observed in this group									
	172	2 26 15	309 22·5	22·5	309 22·50	172										
	173	2 27 50	309 22·5	22·5	309 22·50	173										
	174	2 31 28	309 27·0	26·5	309 26·75	174										
XXXII. Dec. 13, 1874 Perseus zone, *c*–*e*	175	0 35 32	56 37·5	37·0	56 37·25	176	0 38 37	124	0·740	123	2·741	24	1·220	23	3·225	+ 199·5476
	178	0 46 29	56 35·25	35·0	56 35·13	177	0 40 52	25	1·388	24	3·390	123	1·252	122	3·263	− 195·8684
	...	...	...	...	...	179	0 49 35	25	1·361	24	3·363	123	1·284	122	3·279	− 195·9185
	181	0 56 12	56 37·5	37·5	56 37·50	180	0 53 41	124	1·192	123	2·786	24	1·192	23	3·200	+ 199·6183

140. Scale B. ; preceding div. of scale altered from 75 ; following div. altered from 74.

Group	Chron. corr.	Bar.	Ther.	Group	Chron. corr.	Bar.	Ther.
	m. s.	in.	°		m. s.	in.	°
XXV.	+ 1 50	...	...	XXIX.	+ 1 57	30·00	74·3
XXVI.	+ 1 57	30·00	74·0	XXX.	+ 1 57	30·01	73·3
XXVII.	+ 1 57	30·00	74·0	XXXI.	+ 1 57	30·01	73·3
XXVIII.	+ 1 57	30·00	74·3	XXXII.	...	29·98	77·6

Group — Date — Objects	Position Angles					Distances										
	Rotation number	Time by chronometer	Position circle		Mean	Rotation number	Time by chronometer	Scale A				Scale B				Resulting value, Scale A − Scale B corrected for screw and division error
			Vernier I.	II.				Preceding div.		Following div.		Preceding div.		Following div.		
								Scale	Screw	Scale	Screw	Scale	Screw	Scale	Screw	
		h. m. s.	° ′	′	° ′		h. m. s.									
XXXIII.	182	1 3 39	236 37·0	36·5	236 36·75	183	1 6 46	124	1·395	123	3·380	24	1·760	23	3·760	+199·6571
Dec. 13, 1874	185	1 13 46	236 34·5	34·5	236 34·50	184	1 11 16	25	1·900	24	3·902	123	1·875	122	3·872	−195·9714
Perseus zone, *c–e*	...	...	...	...	...	186	1 15 24	25	1·930	24	3·929	123	1·894	122	3·883	−195·9576
	188	1 23 10	236 37·5	37·0	236 37·25	187	1 20 5	124	1·363	123	3·362	24	1·714	23	3·713	+199·6819
XXXIV.	189	1 38 34	226 30·0	29·25	226 29·63	190	1 42 6	101	0·815	100	2·808	48	0·760	47	2·766	+106·0676
Dec. 13, 1874	192	1 47 3	226 25·5	25·0	226 25·25	191	1 45 31	49	0·785	48	2·782	100	1·163	99	3·168	−102·3678
Perseus zone, *b–c*	...	...	...	...	...	193	1 48 25	49	0·770	48	2·765	100	1·159	99	3·157	−102·3764
	195	1 56 9	226 30·5	30·0	226 30·25	194	1 51 9	101	0·814	100	2·813	48	0·766	47	2·770	+106·0646
XXXV.	196	2 4 0	46 30·5	30·0	46 30·25	197	2 6 23	101	0·243	100	2·248	48	0·173	47	2·184	+106·0855
Dec. 13, 1874	199	2 12 24	46 25·0	25·0	46 25·00	198	2 9 25	49	0·214	48	2·204	100	0·624	99	2·630	−102·3952
Perseus zone, *b–c*	...	...	...	...	...	200	2 14 44	49	0·220	48	2·227	100	0·624	99	2·632	−102·3819
	202	2 19 26	46 31·5	31·0	46 31·25	201	2 17 11	101	0·299	100	2·299	48	0·223	47	2·222	+106·0947
XXXVI.	203	2 27 42	80 8·5	8·5	80 8·50	204	2 29 19	124	0·439	123	2·438	24	1·964	23	3·955	+198·5130
Dec. 13, 1874	206	2 35 14	80 6·0	6·0	80 6·00	205	2 32 45	26	0·142	25	2·155	123	0·965	122	2·974	−194·8153
Perseus zone, *e–g*	...	...	...	...	...	207	2 36 35	26	0·140	25	2·148	123	0·954	122	2·960	−194·8071
	209	2 43 6	80 8·0	7·5	80 7·75	208	2 40 7	124	0·498	123	2·499	24	1·992	23	3·992	+198·5299
XXXVII.	210	2 49 31	260 8·5	8·0	260 8·25	211	2 52 48	124	0·576	123	2·570	25	0·070	24	2·073	+198·5363
Dec. 13, 1874	213	2 59 37	260 5·0	5·0	260 5·00	212	2 56 19	26	0·272	25	2·266	123	1·100	122	3·085	−194·8270
Perseus zone, *e–g*	...	...	...	...	...	214	3 1 0	26	0·260	25	2·252	123	1·059	122	3·060	−194·8063
	216	3 7 5	260 8·5	7·5	260 8·00	215	3 4 5	124	0·576	123	2·575	25	0·057	24	2·055	+198·5545
XXXVIII.	217	3 18 42	65 28·5	29·0	65 28·75	218	3 22 29	122	0·240	121	2·249	27	0·255	26	2·264	+190·0189
Dec. 13, 1874	220	3 35 24	65 25·0	25·5	65 25·25	219	3 30 39	28	0·434	27	2·448	121	0·470	120	2·733	−186·2902
Perseus zone, *h–k*	...	...	...	...	...	221	3 37 19	28	0·439	27	2·452	121	0·780	120	2·773	−186·3259
	223	3 42 22	65 28·0	28·0	65 28·00	222	3 40 10	122	0·307	121	2·310	27	0·320	26	2·290	+190·0367
XXXIX.	224	3 49 35	65 28·0	28·0	65 28·00	225	3 52 2	122	0·278	121	2·280	27	0·308	26	2·305	+190·0038
Dec. 13, 1874	227	3 57 36	65 25·0	25·0	65 25·00	226	3 55 28	28	0·485	27	2·482	121	0·785	120	2·790	−186·2999
Perseus zone, *h–k*	...	...	...	...	...	228	3 59 25	28	0·435	27	2·438	121	0·762	120	2·766	−186·3229
	230	4 6 3	65 27·5	27·5	65 27·50	229	4 4 3	122	0·241	121	2·283	27	0·298	26	2·291	+189·9991
XL.	231	0 53 50	65 28·0	28·0	65 28·00	232	0 57 12	121	1·979	120	3·970	27	0·109	26	2·139	+189·8748
Dec. 14, 1874	234	1 3 1	65 25·5	25·5	65 25·50	233	0 59 33	28	0·285	27	2·296	121	0·491	120	2·480	−186·1918
Perseus zone, *h–k*	...	...	...	...	...	235	1 4 1	28	0·283	27	2·280	121	0·493	120	2·490	−186·2066
	237	1 10 1	65 28·0	28·0	65 28·00	236	1 7 1	122	0·017	121	0·025	27	0·161	26	2·158	+189·8886

Group	Chron. corr.	Bar.	Ther.	Group.	Chron. corr.	Bar.	Ther.
	m. s.	in.	°		m. s.	in.	°
XXXIII.	...	29·98	77·6	XXXVII.	...	29·98	77·0
XXXIV.	...	29·99	77·2	XXXVIII.	...	29·99	76·8
XXXV.	...	29·99	77·2	XXXIX.	...	29·99	76·8
XXXVI.	...	29·98	77·0	XL.	...	29·97	79·0

Group — Date — Objects	Position Angles					Distances									Resulting value, Scale A – Scale B corrected for screw and division error
	Rotation number	Time by chronometer	Position circle: Vernier I.	Position circle: II.	Mean	Rotation number	Time by chronometer	Scale A: Preceding div. Scale	Scale A: Preceding div. Screw	Scale A: Following div. Scale	Scale A: Following div. Screw	Scale B: Preceding div. Scale	Scale B: Preceding div. Screw	Scale B: Following div. Scale	Scale B: Following div. Screw	
		h. m. s.	° ′	′	° ′		h. m. s.									
XLI.	238	1 20 59	245 27·5	27·0	245 27·25	239	1 23 48	122	0·446	121	2·448	27	0·560	26	2·551	+189·9198
Dec. 14, 1874	241	1 28 10	245 25·5	25·0	245 25·25	240	1 26 40	28	0·704	27	2·695	121	0·961	120	2·962	−186·2622
Perseus zone, *h–k*	…	…	…	…	…	242	1 30 28	28	0·685	27	2·695	121	0·943	120	2·952	−186·2582
	244	1 35 2	245 28·5	28·0	245 28·25	243	1 32 33	122	0·440	121	2·460	27	0·545	26	2·553	+189·9292
XLII.	245	1 54 44	251 34·5	34·0	251 34·25	246	1 56 7	106	0·580	105	2·585	42	1·955	41	3·934	+126·6666
Dec. 14, 1874	248	2 1 17	251 30·0	29·5	251 29·75	247	1 58 23	43	1·990	42	4·010	105	0·990	104	3·005	−122·9807
Perseus zone, *g–h*	…	…	…	…	…	249	2 3 15	44	0·042	43	2·030	105	1·015	104	3·028	−122·9709
	251	2 7 54	251 33·5	33·5	251 33·50	250	2 5 34	106	0·670	105	2·650	42	1·991	41	3·988	+126·6979
XLIII.	252	2 23 56	71 34·0	34·0	71 34·00	253	2 27 35	106	0·915	105	2·912	43	0·259	42	2·260	+126·6782
Dec. 14, 1874	255	2 33 15	71 30·0	30·0	71 30·00	254	2 31 6	44	0·283	43	2·283	105	0·314	104	2·314	−123·0145
Perseus zone, *g–h*	…	…	…	…	…	256	2 35 0	44	0·295	43	2·293	105	0·287	104	2·309	−122·9879
	258	2 41 9	71 34·0	34·5	71 34·25	257	2 38 19	106	0·892	105	2·906	43	0·230	42	2·235	+126·6899
XLIV.	259	2 58 24	56 38·0	38·5	56 38·25	260	3 1 12	124	1·320	123	3·305	24	1·570	23	3·557	+199·7821
Dec. 14, 1874	262	3 7 21	56 35·0	35·5	56 35·25	261	3 3 53	25	1·745	24	3·740	123	1·845	122	3·843	−196·1015
Perseus zone, *c–e*	…	…	…	…	…	263	3 9 44	25	1·737	24	3·734	123	1·826	122	3·825	−196·0898
	265	3 15 57	56 37·5	37·5	56 37·50	264	3 12 46	124	1·326	123	3·325	24	1·575	23	3·567	+199·7904
XLV.	266	3 21 10	236 37·5	37·5	236 37·50	267	3 22 26	124	1·022	123	3·021	24	1·247	23	3·229	+199·8145
Dec. 14, 1874	269	3 28 40	236 36·0	35·5	236 35·75	268	3 24 52	25	1·441	24	3·452	123	1·532	122	3·518	−196·0788
Perseus zone, *c–e*	…	…	…	…	…	270	3 31 53	25	1·466	24	3·463	123	1·555	122	3·561	−196·0939
	272	3 38 58	236 38·5	38·5	236 38·50	271	3 35 53	124	1·053	123	3·053	24	1·283	23	3·275	+199·8120
XLVI.	273	4 43 35	173 35·0	35·5	173 35·25	274	4 45 27	93	1·562	92	3·574	55	1·736	54	3·725	+ 75·8597
Dec. 14, 1874	276	4 49 46	173 38·0	38·0	173 38·00	275	4 48 2	56	1·660	55	3·670	92	1·870	91	3·864	− 72·1769
Hydra zone, *e–f*	…	…	…	…	…	277	4 53 26	56	1·661	55	3·672	92	1·872	91	3·868	− 72·1785
	279	4 58 17	173 37·0	37·5	173 37·25	278	4 55 36	93	1·580	92	3·565	55	1·701	54	3·710	+ 75·8890
XLVII.	280	5 4 58	353 38·0	38·0	353 38·00	281	5 7 38	93	1·313	92	3·327	55	1·463	54	3·476	+ 75·8753
Dec. 14, 1874	283	5 13 3	353 38·0	38·5	353 38·25	282	5 10 16	56	1·443	55	3·434	92	1·640	91	3·637	− 72·1716
Hydra zone, *e–f*	…	…	…	…	…	284	5 14 44	56	1·430	55	3·432	92	1·625	91	3·625	− 72·1656
	286	5 19 33	353 37·5	38·0	353 37·75	285	5 21 20	93	1·335	92	3·330	55	1·485	54	3·473	+ 75·8781
XLVIII.	287	2 59 55	80 9·0	9·5	80 9·25	288	3 2 13	124	0·569	123	2·570	25	0·065	24	2·063	+198·5420
Dec. 16, 1874	290	3 8 37	80 5·5	6·0	80 5·75	289	3 6 21	26	0·241	25	2·242	123	1·096	122	3·091	−194·8520
Perseus zone, *e–g*	…	…	…	…	…	291	3 11 4	26	0·214	25	2·229	123	1·070	122	3·068	−194·8469
	293	3 17 53	80 9·5	9·0	80 9·25	292	3 14 21	124	0·590	123	2·587	25	0·080	24	2·076	+198·5469

Group	Chron. corr.	Bar.	Ther.	Group	Chron. corr.	Bar.	Ther.
	m. s.	in.	°		m. s.	in.	°
XLI.	…	29·97	79·0	XLV.	…	30·10	76·0
XLII.	…	30·01	77·0	XLVI.	−0 40	29·99	75·0
XLIII.	…	30·01	77·0	XLVII.	−0 40	29·99	75·0
XLIV.	…	30·10	76·0	XLVIII.	…	30·01	76·5

Group — Date — Objects	Position Angles					Distances									
	Rotation number	Time by chronometer	Position circle		Mean	Rotation number	Time by chronometer	Scale A				Scale B				Resulting value, Scale A − Scale B corrected for screw and division error
			Vernier I.	II.				Preceding div.		Following div.		Preceding div.		Following div.		
								Scale	Screw	Scale	Screw	Scale	Screw	Scale	Screw	
		h. m. s.	° ′	′	° ′		h. m. s.									
XLIX.	294	3 31 12	149 56·5	56·5	149 56·50	295	3 34 19	105	0·523	104	2·530	44	0·234	43	2·225	+122·3230
Dec. 16, 1874	297	3 47 54	149 50·5	51·5	149 51·00	296	3 39 30	45	0·285	44	2·284	104	0·935	103	2·920	−118·6242
Hydra zone,	...	...	...	...	...	298	3 49 38	45	0·273	44	2·280	104	0·926	103	2·921	−118·6279
d–e	300	3 55 15	149 55·5	55·5	149 55·50	299	3 53 39	105	0·540	104	2·548	44	0·225	43	2·229	+122·3429
L.	301	4 1 55	329 55·5	55·0	329 55·25	302	4 3 23	105	0·599	104	2·615	44	0·291	43	2·310	+122·3319
Dec. 16, 1874	304	4 8 5	329 50·5	50·5	329 50·50	303	4 5 34	45	0·350	44	2·361	104	1·000	103	3·005	−118·6298
Hydra zone,	...	...	...	...	...	305	4 10 48	45	0·345	44	2·359	104	0·991	103	2·976	−118·6139
d–e	307	4 23 20	329 55·5	55·0	329 55·25	306	4 13 30	105	0·600	104	2·594	44	0·290	43	2·275	+122·3396
LI.*	308	4 8 54	162 4·0	4·5	162 4·25	309	4 22 38	96	1·209	95	3·210	52	1·994	51	3·995	+ 87·2366
Dec. 21, 1874	311	4 44 28	161 57·0	57·0	161 57·00	310	4 41 26	53	1·975	52	3·967	95	1·530	94	3·538	− 83·5352
Hydra zone,	...	...	...	...	...	312	4 47 46	53	1·983	52	3·991	95	1·500	94	3·552	− 83·5359
c–d	314	4 54 4	162 5·0	5·0	162 5·00	313	4 50 53	96	1·229	95	3·225	53	0·040	52	2·020	+ 87·2212
LII.*	315	5 7 27	342 6·0	5·5	342 5·75	316	5 12 20	96	1·060	95	3·071	52	1·880	51	3·879	+ 87·2153
Dec. 21, 1874	318	5 36 19	341 57·5	57·0	341 57·25	317	5 33 17	53	1·820	52	3·828	95	1·389	94	3·395	− 83·5413
Hydra zone,	...	...	...	...	...	319	5 38 0	53	1·852	52	3·842	95	1·394	94	3·410	− 83·5282
c–d	321	5 42 17	342 6·0	5·5	342 5·75	320	5 40 5	96	1·075	95	3·074	52	1·871	51	3·878	+ 87·2293
LIII.	322	5 50 49	337 20·0	20·0	337 20·00	323	5 52 16	95	1·568	94	3·575	53	1·435	52	3·439	+ 84·1572
Dec. 21, 1874	325	5 57 40	337 12·0	12·0	337 12·00	324	5 54 47	54	1·411	53	3·392	94	1·920	93	3·905	− 80·4861
Hydra zone,	...	...	...	...	...	326	5 59 23	54	1·380	53	3·373	94	1·905	93	3·890	− 80·4955
b–c	328	6 5 25	337 22·0	21·5	337 21·75	327	6 2 58	95	1·572	94	3·565	53	1·435	52	3·434	+ 84·1568
LIV.	329	6 11 35	157 21·0	21·0	157 21·00	330	6 13 10	95	1·711	94	3·710	53	1·579	52	3·575	+ 84·1531
Dec. 21, 1874	332	6 18 12	157 14·0	13·5	157 13·75	331	6 15 21	54	1·562	53	3·555	95	0·018	94	2·020	− 80·4348
Hydra zone,	...	...	...	...	...	333	6 20 22	54	1·559	53	3·566	95	0·050	94	2·043	− 80·4587
b–c	335	6 25 9	157 21·5	21·5	157 21·50	334	6 23 2	95	1·728	94	3·728	53	1·600	52	3·601	+ 84·1472
LV.	336	6 32 21	171 27·0	26·5	171 26·75	337	6 35 1	98	1·112	97	3·122	51	0·055	50	2·070	+ 95·0757
Dec. 21, 1874	339	6 40 37	171 19·5	19·5	171 19·50	338	6 37 45	52	0·052	51	2·044	97	1·452	96	3·474	− 91·3870
Hydra zone,	...	...	...	...	...	340	6 42 7	52	0·041	51	2·050	97	1·471	96	3·470	− 91·3970
a–b	342	6 49 33	171 27·5	27·5	171 27·50	341	6 47 27	98	1·110	97	3·133	51	0·053	50	2·045	+ 95·0938
LVI.	343	6 54 18	351 26·5	26·5	351 26·50	344	6 55 55	98	0·875	97	2·880	50	1·835	49	3·833	+ 95·0609
Dec. 21, 1874	346	7 1 32	351 19·0	19·0	351 19·00	345	6 59 59	51	1·800	50	3·814	97	1·220	96	3·211	− 91·3922
Hydra zone,	...	...	...	...	...	347	7 3 30	51	1·800	50	3·784	97	1·190	96	3·200	− 91·3870
a–b	349	7 7 48	351 25·5	25·5	351 25·50	348	7 5 41	98	0·846	97	2·849	50	1·825	49	3·805	+ 95·0497

LI. and LII. Great delay from cloud.

Group	Chron. corr.	Bar.	Ther.	Group	Chron. corr.	Bar.	Ther.
	m. s.	in.	°		m. s.	in.	°
XLIX.	−0 27	30·02	76·3	LIII.	−0 7	29·96	74·1
L.	−0 27	30·02	76·3	LIV.	−0 7	29·96	74·1
LI.	−0 7	29·99	76·0	LV.	−0 7	29·95	74·0
LII.	−0 7	29·99	76·0	LVI.	−0 7	29·95	74·0

Group — Date — Objects	Position Angles					Distances									
	Rotation number	Time by chronometer	Position circle		Mean	Rotation number	Time by chronometer	Scale A				Scale B				Resulting value, Scale A − Scale B corrected for screw and division error
			Vernier I.	II.				Preceding div.		Following div.		Preceding div.		Following div.		
								Scale	Screw	Scale	Screw	Scale	Screw	Scale	Screw	
		h. m. s.	° ′	′	° ′		h. m. s.									
LVII.	350	4 9 18	158 56·0	56·5	158 56·25	351	4 13 53	122	0·450	121	2·465	26	1·087	25	3·100	+192·3850
Dec. 22, 1874	353*	4 18 21	158 55·0	54·5	158 54·75	352	4 16 16	27	1·242	26	3·258	121	1·955	120	3·952	−188·7045
Hydra zone, *d–f*	...	...	...	...	...	354*	4 44 19	27	1·249	26	3·260	121	1·973	120	3·975	−188·7209
	356	4 58 59	158 57·5	57·0	158 57·25	355	4 48 59	122	0·428	121	2·450	26	1·100	25	3·095	+192·3626
LVIII.	357	4 55 47	338 55·5	55·5	338 55·50	358	4 57 58	122	1·413	121	3·421	26	1·060	25	3·072	+192·3759
Dec. 22, 1874	360	5 2 34	338 53·0	52·5	338 52·75	359	5 0 19	27	1·233	26	3·240	121	1·933	120	3·945	−188·6975
Hydra zone, *d–f*	...	...	...	...	...	361	5 4 35	27	1·198	26	3·202	121	1·930	120	3·928	−188·7234
	363	5 10 23	338 57·0	57·0	338 57·00	362	5 9 27	122	1·441	121	3·442	26	1·060	25	3·076	+192·3982
LIX.*	364	5 33 12	348 2·5	2·5	348 2·50	365	5 35 44	132	0·643	131	2·630	16	1·694	15	3·692	...
Dec. 22, 1874	367*	5 49 3	348 1·0	1·5	348 1·25	366*	5 38 29	17	1·929	16	3·941	131	1·222	130	3·224	...
Hydra zone, *a–d*	...	...	...	...	...	368	5 45 4	17	1·900	16	3·915	131	1·195	130	3·196	...
	370	5 52 59	348 3·0	3·5	348 3·25	369	5 48 48	132	0·615	131	2·608	16	1·690	15	3·685	...
LX.*	371	6 14 28	168 3·0	2·5	168 2·75	372	6 15 43	132	0·779	131	2·786	16	1·832	15	3·840	...
Dec. 22, 1874	374	6 22 44	168 1·0	1·0	168 1·00	373	6 18 54	18	0·075	17	2·083	131	1·330	130	3·335	...
Hydra zone, *a–d*	...	...	...	...	...	375	6 24 25	18	0·064	17	2·050	131	1·352	130	3·338	...
	...	...	...	...	...	376	6 32 28	132	0·795	131	2·811	16	1·850	15	3·853	...
LXI.	377	6 21 19	164 47·5	47·5	164 47·50	378	6 23 18	118	1·331	117	3·345	30	1·326	29	3·332	+176·0307
Dec. 23, 1874	380	6 27 16	164 45·5	45·5	164 45·50	379	6 25 48	31	1·464	30	3·469	117	1·834	116	3·830	−172·3574
Hydra zone, *a–c*	...	...	...	...	...	381	6 30 0	31	1·465	30	3·456	117	1·812	116	3·815	−172·3447
	383	6 40 14	164 47·5	47·5	164 47·50	382	6 32 29	118	1·348	117	3·341	30	1·320	29	3·304	+176·0540
LXII.	...	...	...	...	...	385	6 46 36	118	1·251	117	3·265	30	1·248	29	3·260	+176·0269
Dec. 23, 1874	...	...	...	...	...	386	6 50 36·5	31	1·389	30	3·395	117	1·756	116	3·769	−172·3576
Hydra zone, *a–c*	...	...	...	...	...	388	6 54 14	31	1·351	30	3·371	117	1·758	116	3·761	−172·3851
	...	...	...	...	...	389	6 56 45	118	1·290	117	3·280	30	1·260	29	3·275	+176·0401
LXIII.	391	9 50 15	339 55·0	...	339 55·0	392	9 55 5	144	0·305	143	2·300	5	0·683	4	2·700	+277·7089
Dec. 24, 1874	394	10 2 10	339 53·0	...	339 53·0	393	9 59 9	6	1·020	5	3·020	143	0·949	142	2·950	−273·9735
Hydra zone, *c–f*	...	...	...	...	...	395	10 3 44	6	1·019	5	3·026	143	0·960	142	2·967	−273·9851
	397	10 36 50	339 55·0	...	339 55·0	396	10 8 30	144	0·291	143	2·300	5	0·724	4	2·742	+277·6610
LXIV.	399	3 31 15	159	53·5	159 53·5	400	3 33 43	144	0·152	143	2·156	5	0·500	4	2·500	+277·7540
Dec. 26, 1874	402	3 44 37	159	50·5	159 50·5	401	3 43 13	6	0·853	5	2·850	143	0·845	142	2·834	−274·0332
Hydra zone, *c–f*	...	...	...	...	...	403	3 47 59	6	0·839	5	2·845	143	0·875	142	2·867	−274·0745
	404 bis	3 56 36	159	53·0	159 53·0	404	3 53 20	144	0·226	143	2·225	5	0·497	4	2·574	+277·8144

353 and 354; 366 and 367. Delay from cloud between these observations.

LIX. and LX. Wrong stars observed.

Group	Chron. corr.	Bar.	Ther.	Group	Chron. corr.	Bar.	Ther.
	h. m. s.	in.	°		h. m. s.	in.	°
LVII.	−0 0 3	29·99	76·0	LXI.	−2 0 16	30·01	77·5
LVIII.	−0 0 3	29·99	76·0	LXII.	−2 0 14	30·01	77·5
LIX.	−0 0 3	29·98	75·0	LXIII.	+0 0 7	29·98	77·2
LX.	−0 0 3	29·98	75·0	LXIV.	+0 0 15	29·98	78·0

Group — Date — Objects	Position Angles: Rotation number	Time by chronometer	Position circle: Vernier I.	Position circle: II.	Mean	Distances: Rotation number	Time by chronometer	Scale A: Preceding div. Scale	Scale A: Preceding div. Screw	Scale A: Following div. Scale	Scale A: Following div. Screw	Scale B: Preceding div. Scale	Scale B: Preceding div. Screw	Scale B: Following div. Scale	Scale B: Following div. Screw	Resulting value, Scale A − Scale B corrected for screw and division error
		h. m. s.	°	′	° ′		h. m. s.									
LXV.	405	3 59 57	239	55·0	239 55·0	406	4 1 27	144	0·144	143	2·157	5	0·429	4	2·452	+277·8092
Dec. 26, 1874	408	4 9 20	240	0·5	240 0·5	407	4 6 14	6	0·813	5	2·826	143	0·802	142	2·802	−274·0278
Hydra zone, *c–f*	...	...	...	...	...	409	4 10 45	6	0·782	5	2·778	143	0·760	142	2·763	−274·0268
	411	4 16 19	239	53·5	239 53·5	410	4 14 11	144	0·178	143	2·172	5	0·450	4	2·451	+277·8237
LXVI.	412	4 28 24	343	54·0	343 54·0	413	4 31 15	139	1·930	138	3·928	9	0·546	8	2·548	+261·4737
Dec. 26, 1874	415*	4 41 19	348	50·5	348 50·5	414	4 36 12	10	0·889	9	2·891	139	0·522	138	2·537	−257·6752
Hydra zone, *a–d*	...	...	...	...	...	416	4 41 55	10	0·859	9	2·864	139	0·501	138	2·517	−257·6839
	418*	4 46 48	348	53·5	348 53·5	417	4 44 57	139	1·943	138	3·935	9	0·571	8	2·585	+261·4531
LXVII.	419	4 50 56	163	53·0	163 53·0	420	4 52 1	140	0·030	139	2·032	9	0·645	8	2·641	+260·4838
Dec. 26, 1874	422*	4 59 2	164	50·5	164 50·5	421	4 55 56	10	1·000	9	3·004	139	0·623	138	2·639	−258·6610
Hydra zone, *a–d*	...	...	...	...	...	423	5 1 11	10	0·985	9	2·993	139	0·619	138	2·638	−258·6716
	425	5 6 37	163	53·5	163 53·5	424	5 4 45	140	0·040	139	2·050	9	0·680	8	2·670	+260·4662
LXVIII.	425 bis	5 13 20	154	55·5	154 55·5	426	5 14 54	126	0·591	125	2·603	22	1·972	21	3·990	+206·6506
Dec. 26, 1874	428	5 42 46	154	53·5	154 53·5	427	5 18 8	24	0·220	23	2·213	125	1·122	124	3·111	−202·8849
Hydra zone, *c–e*	...	...	...	...	...	429	5 43 35	24	0·225	23	2·235	125	1·129	124	3·122	−202·8808
	431	5 48 55	154	57·0	154 57·0	430	5 47 12	126	0·626	125	2·626	23	0·004	22	2·004	+206·6608
LXIX.	432	5 52 13	334	56·5	334 56·5	433	5 52 59	126	0·490	125	2·503	22	1·872	21	3·875	+206·6600
Dec. 26, 1874	435	5 58 12	334	53·5	334 53·5	434	5 56 23	24	0·102	23	2·095	125	0·999	124	2·998	−202·8831
Hydra zone, *c–e*	...	...	...	...	...	436	5 59 22	24	0·090	23	2·096	125	0·972	124	2·959	−202·8555
	438	6 3 55	334	56·0	334 56·0	437	6 2 14	126	0·485	125	2·485	22	1·876	21	3·878	+206·6450
LXX.	Position angles were not observed					440	6 11 6	122	1·385	121	3·394	26	0·961	25	2·957	+192·4593
Dec. 26, 1874						441	6 17 0	27	1·160	26	3·152	121	1·830	120	3·825	−188·6721
Hydra zone, *d–f*						443	6 19 42	27	1·160	26	3·155	121	1·822	120	3·810	−188·6590
						444	6 23 2	122	1·364	121	3·354	26	0·972	25	2·956	+192·4238
LXXI.	Position angles were not observed					445	6 29 24	122	1·560	121	3·558	26	1·130	25	3·132	+192·4512
Dec. 26, 1874						446	6 37 7	27	1·340	26	3·350	122	0·022	121	2·025	−188·6779
Hydra zone, *d–f*						447	6 41 19	27	1·344	26	3·334	122	0·031	121	2·022	−188·6868
						448	6 47 6	122	1·575	121	3·595	26	1·135	25	3·130	+192·4756

415 and 418. Vernier I. is probably 343°.

422. Vernier I. is probably 163°.

Group	Chron. corr.	Bar.	Ther.	Group	Chron. corr.	Bar.	Ther.
	m. s.	in.	°		m. s.	in.	°
LXV.	+0 15	29·98	78·0	LXIX.	+0 15	29·96	77·1
LXVI.	+0 15	29·96	77·1	LXX.	+0 15	29·96	77·0
LXVII.	+0 15	29·96	77·1	LXXI.	+0 15	29·96	77·0
LXVIII.	+0 15	29·96	77·1				

Table II.

RESULTS OF STAR MEASURES.

No. of group — Date — Name of objects	Position Angles: Rotation number	Hour angle	Observed position angle	Refraction	Aberration, &c.	Proper motion	Sum	Values of ψ & μ	Distances: Rotation number	Hour angle	Sc. A − Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Mean	Aberration	Proper motion	Distance, 1874·0 in screw revolutions
		h. m.	° ′	′	′	...	° ′	...		h. m.	rev.	rev.	rev.	rev.	rev.	rev.	rev.
I. Nov. 13, 1874 *a* Piscium	1 bis	...	136 25·0	...	...	...	...	...	1	...	+ 0·2358	...	...	0·2382	...	...	0·2382
	2 „	...	143 43·0	...	...	...	...		2	...	− 0·2288	...	...				
	3 „	...	327 20·0	...	...	...	...	...	3	...	− 0·2475	...	...				
	4 „	...	317 13·0	...	...	...	...		4	...	+ 0·2405	...	...				
App. index error 1·6420																	
II. Nov. 21, 1874 *a* Piscium	5 bis	...	321 20·0	...	...	...	...	...	5	...	− 0·2467	...	...	0·2448	...	...	0·2448
	6 „	...	321 59·5	...	...	...	...		6	...	+ 0·2372	...	...				
	7 „	...	...	...	...	...	...	...	7	...	+ 0·2524	...	...				
	8 „	...	141 28·5	...	...	...	...		8	...	− 0·2429	...	...				
App. index error 1·8880																	
III. Nov. 23, 1874 ζ Piscium	9 bis	...	245 16·5	...	...	..	...	...	9	...	+ 0·4620	...	...	0·4631	...	...	0·4631
	10 „	...	242 5·5	...	...	...	...		10	...	− 0·4746	...	...				
	11 „	...	242 4·0	...	...	...	...	...	11	...	− 0·4588	...	...				
	12 „	...	244 40·0	...	...	..	...		12	...	+ 0·4569	...	...				
App. index error 1·8850																	
IV. Nov. 23, 1874 ζ Piscium	13 bis	...	244 14·0	...	...	...	...	...	13	...	+ 0·4540	...	...	0·4686	...	...	0·4686
	14 „	...	242 16·0	...	...	...	...		14	...	− 0·4562	...	...				
	15 „	...	243 35·0	...	...	...	...	...	15	...	− 0·4727	...	...				
	16 „	...	242 50·0	...	...	...	...		16	...	+ 0·4914	...	...				
App. index error 1·8850																	
V. Nov. 29, 1874 Castor	17 bis	...	230 7·50	...	...	...	...	...	17	...	− 0·4410	...	...	0·4439	...	...	0·4439
	18 „	...	244 42·50	...	...	...	...		18	...	+ 0·4381	...	...				
	19 „	...	62 54·50	...	...	...	...	...	19	...	+ 0·4497	...	...				
	20 „	...	50 20·50	...	...	...	...		20	...	− 0·4466	...	...				
App. index error 1·8570																	
VI. Dec. 1, 1874 τ^6 & τ^7 Eridani	21	20 43·3	163 55·75	−0·62	·00	...	163 55·13	1″·91	22	20 42·4	+ 93·6374	0·0264	93·6638	93·6657	−·0029	...	93·6628
	24	20 51·3	163 51·88	0·56	·00	...	163 51·32		23	20 47·7	− 93·6393	0·0264	93·6657				
	...	...	...	...	...	...	...	1″·34	25	20 53·8	(−93·8492)	0·0264	(93·8756)				
	27	21 3·4	163 55·63	−0·50	·00	...	163 55·13		26	20 57·1	+ 93·6411	0·0264	93·6675				
App. index error 1·8495																	
VII. Dec. 1, 1874 τ^6 & τ^7 Eridani	28	21 7·0	163 54·88	−0·48	·00	...	163 54·40	1″·49	29	21 8·8	+ 93·6416	0·0263	93·6679	93·6698	−·0029	...	93·6669
	31	21 27·4	163 51·88	0·41	·00	...	163 51·47		30	21 13·0	− 93·6475	0·0263	93·6738				
	...	...	...	...	...	...	...	1″·05	32	21 30·0	− 93·6395	0·0263	93·6658				
	34	21 35·3	163 54·88	−0·38	·00	...	163 54·50		33	21 34·7	+ 93·6453	0·0263	93·6716				
App. index error 1·8532																	
VIII. Dec. 1, 1874 ξ^1 & ξ^2 Can. Maj.	35	20 11·0	57 38·00	+0·13	−·16	...	57 37·97	1″·26	36	20 12·9	+120·7427	0·0792	120·8219	120·8044	+·0042	...	120·8086
	38	20 18·4	57 35·63	0·06	·16	...	57 35·53		37	20 15·5	−120·7260	0·0771	120·8031				
	...	...	...	...	...	...	...	1″·14	39	20 19·9	−120·7318	0·0739	120·8057				
	41	20 25·5	57 38·25	+0·04	−·16	...	57 38·13		40	20 23·1	+120·7151	0·0718	120·7869				
App. index error 1·8574																	

No. of group — Date — Name of objects	Position Angles								Distances								
	Rotation number	Hour angle	Observed position angle	Refraction	Aberration, &c.	Proper motion	Sum	Values of ψ & μ	Rotation number	Hour angle	Sc. A − Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Mean	Aberration	Proper motion	Distance, 1874·0 in screw revolutions
		h. m.	° ′ ″	′	′	′	° ′ ″			h. m.	rev.	rev.	rev.	rev.	rev.	rev.	rev.
IX. Dec. 1, 1874 ξ^1 & ξ^2 Can. Maj.	42	20 29·1	57 37·88	+0·02	−·16	...	57 37·74	1″·07	43	20 30·2	+120·7274	0·0673	120·7947	120·7950	+·0042	...	120·7992
	45	20 36·3	57 35·50	0·00	·16	...	57 35·34		44	20 34·6	−120·7181	0·0648	120·7829				
	...	...	...	...	...	...	...	0″·96	46	20 37·8	−120·7441	0·0630	120·8071				
	48	20 42·5	57 37·38	−0·02	−·16	...	57 37·20		47	20 40·2	+120·7333	0·0618	120·7951				
App. index error 1·8578																	
X. Dec. 1, 1874 P. A. stars, γ & δ	49	19 37·3	129 21·50	−2·10	−·22	...	129 19·18	1″·13	50	19 38·7	+ 93·6703	0·0572	93·7275	93·7278	+·0058	...	93·7336
	52	19 42·8	129 19·38	1·94	·22	...	129 17·22		51	19 41·1	− 93·6775	0·0561	93·7336				
	...	...	...	...	...	...	...	0″·80	53	19 44·2	− 93·6673	0·0547	93·7220				
	55	19 50·1	129 21·75	−1·75	−·22	...	129 19·78		54	19 46·6	+ 93·6742	0·0537	93·7279				
App. index error 1·8364																	
XI. Dec. 1, 1874 P. A. stars, γ & δ	56	19 52·4	129 22·00	−1·69	−·22	...	129 20·09	1″·78	57	19 55·2	+ 93·6898	0·0523	93·7421	93·7317	+·0058	...	93·7375
	59	20 1·9	129 18·50	1·49	·22	...	129 16·79		58	19 58·8	− 93·6888	0·0492	93·7380				
	...	...	...	...	...	...	...	1″·25	60	20 5·5	− 93·6783	0·0471	93·7254				
	62	20 12·6	129 22·13	−1·30	−·22	...	129 20·61		61	20 8·2	+ 93·6750	0·0463	93·7213				
App. index error 1·8636																	
XII. Dec. 1, 1874 Δ 23	63 bis	...	204 39·25	...	...	...	...	...	63	...	+ 0·1511	...	...	0·1444	...	...	0·1444
	64 „	...	...	...	...	...	...		64	...	− 0·1326	...	...				
	65 „	...	345 37·00	...	...	...	...	...	65	...	− 0·1556	...	...				
	66 „	...	32 45·50	...	...	...	...		66	...	+ 0·1383	...	...				
App. index error 1·8580																	
XIII. Dec. 2, 1874 Perseus zone, *i*–*k*	67	22 42·5	48 24·00	−0·72	−·30	−·21	48 22·77	1″·50	68	22 44·2	+112·8078	0·1032	112·9110	112·9163	−·0038	−·0046	112·9079
	70	22 51·5	48 21·50	0·77	·30	·21	48 20·22		69	22 47·6	−112·8275	0·1006	112·9281				
	...	...	...	...	...	...	...	1″·27	71	22 53·1	−112·8317	0·0968	112·9285				
	73	22 58·5	48 25·00	−0·82	−·30	−·21	48 23·67		72	22 56·3	+112·8030	0·0945	112·8975				
App. index error 1·8500																	
XIV. Dec. 2, 1874 Perseus zone, *i*–*k*	74	23 0·4	48 25·00	−0·83	−·30	−·21	48 23·66	1″·25	75	23 2·6	+112·8199	0·0907	112·9106	112·9000	−·0038	−·0046	112·8916
	77	23 7·3	48 22·25	0·89	·30	·21	48 20·85		76	23 5·1	−112·8046	0·0892	112·8938				
	...	...	...	...	...	...	...	1″·06	78	23 9·8	−112·7935	0·0865	112·8800				
	80	23 14·8	48 24·50	−0·95	−·30	−·21	48 23·04		79	23 12·2	+112·8306	0·0850	112·9156				
App. index error 1·8500																	
XV. Dec. 2, 1874 Perseus zone, *h*–*i*	81	23 25·3	87 50·50	−0·29	−·31	+·03	87 49·93	2′·44	82	23 28·5	+ 86·4968	0·0254	86·5222	86·5200	−·0028	+·0052	86·5224
	...	...	...	...	...	...	...		83	23 31·3	− 86·4908	0·0254	86·5162				
	84	23 33·9	87 45·75	0·24	·31	·03	87 45·23	1″·58	85	23 36·2	− 86·5015	0·0247	86·5262				
	87	23 44·8	87 50·75	−0·17	−·31	+·03	87 50·30		86	23 39·9	+ 86·4908	0·0247	86·5155				
App. index error 1·8500																	
XVI. Dec. 3, 1874 Perseus zone, *g*–*h*	88	21 12·7	71 33·25	−1·66	−·32	+·07	71 31·34	1′·62	89	0 7·6	+124·6667	0·0402	124·7069	124·7385	−·0041	+·0013	124·7357
	91	21 26·4	71 29·75	1·49	·32	·07	71 28·01		90	0 10·6	−124·6915	0·0395	124·7310				
	...	...	...	...	...	...	...	1″·51	92	0 18·9	−124·7228	0·0376	124·7604				
	94	21 37·8	71 32·75	−1·36	−·32	+·07	71 31·14		93	0 22·5	+124·7184	0·0372	124·7556				
App. index error 1·8565																	

No. of group — Date — Name of objects	Position Angles: Rotation number	Hour angle	Observed position angle	Refraction	Aberration, &c.	Proper motion	Sum	Values of ψ & μ	Distances: Rotation number	Hour angle	Sc. A − Sc. P + approx. index correction	Refraction	Resulting dist. in screw revolutions	Mean	Aberration	Proper motion	Distance, 1874·0 in screw revolutions
		h. m.	° ′	′	′	′	° ′			h. m.	rev.	rev.	rev.	rev.	rev.	rev.	rev.
XVII.	95	21 40·5	71 32·50	−1·34	−·32	+·07	71 30·91	1′·07	96	0 29·9	+ ...	0·0364	...				
Dec. 3, 1874	98	21 49·4	71 30·00	1·28	·32	·07	71 28·47		97	0 34·5	−124·7438	0·0360	124·7798	124·7877	−·0041	+·0013	124·7849
Perseus zone, *g–h*	...	...	...	...	...	...	...	1″·00	99	0 38·9	−124·7565	0·0353	124·7918				
	101	21 59·1	71 31·75	−1·21	−·32	+·07	71 30·29		100	0 44·1	+124·7571	0·0345	124·7916				
App. index error 1·8565																	
XVIII.	102	22 0·2	70 11·25	−1·23	−·33	+·03	70 9·72	0′·81	103	22 1·9	+111·1321	0·1093	111·2414				
Dec. 3, 1874	105	22 10·6	70 9·75	1·17	·33	·03	70 8·28		104	22 7·4	−111·1645	0·1029	111·2674	111·2522	−·0035	+·0003	111·2490
Perseus zone, *f–g*	...	...	...	...	...	...	...	0″·67	106	22 12·3	−111·1574	0·0975	111·2549				
	108	22 17·1	70 11·50	−1·14	−·33	+·03	70 10·06		107	22 16·7	+111·1544	0·0908	111·2452				
App. index error 1·8565																	
XIX.	109	22 18·7	70 11·25	−1·13	−·33	+·03	70 9·82	1′·12	110	22 24·5	+111·1756	0·0857	111·2613				
Dec. 3, 1874	112	22 30·0	70 9·00	1·08	·33	·03	70 7·62		111	22 28·1	−111·1639	0·0829	111·2468	111·2518	−·0035	+·0003	111·2486
Perseus zone, *f–g*	...	...	...	...	...	...	...	0″·94	113	22 31·6	−111·1647	0·0797	111·2444				
	115	22 38·4	70 11·25	−1·05	−·33	+·03	70 9·90		114	22 35·2	+111·1775	0·0770	111·2545				
App. index error 1·8565																	
XX.	116	22 44·4	92 32·50	−0·42	−·34	−·13	92 31·61	1′·06	117	22 46·4	+ 88·9977	0·0307	89·0284				
Dec. 3, 1874	119	22 52·7	92 30·25	0·35	·34	·13	92 29·43		118	22 49·7	− 88·9939	0·0300	89·0239	89·0309	−·0027	−·0054	89·0228
Perseus zone, *e–f*	...	...	...	...	...	...	...	0″·71	120	22 54·3	− 88·9890	0·0292	89·0182				
	122	23 0·7	92 32·25	−0·28	−·34	−·13	92 31·50		121	22 57·7	+ 89·0246	0·0285	89·0531				
App. index error 1·8565																	
XXI.	123	23 13·3	92 32·25	−0·18	−·34	−·13	92 31·60	1′·14	124	22 15·2	+ 89·0110	0·0258	89·0368				
Dec. 3, 1874	126	23 29·7	92 31·25	−0·08	·34	·13	92 30·70		125	22 21·9	− 89·0236	0·0258	89·0494	89·0484	−·0027	−·0054	89·0403
Perseus zone, *e–f*	...	...	...	...	...	...	...	0″·76	127	22 47·5	− 89·0292	0·0239	89·0531				
	129	23 53·8	92 34·75	+0·07	−·34	−·13	92 34·35		128	22 50·4	+ 89·0305	0·0239	89·0544				
App. index error 1·8565																	
XXII.	130	1 56·3	163 57·25	−0·29	−·01	...	163 56·95	3′·32									
Dec. 4, 1874	131	1 59·4	163 50·50	0·30	·01	...	163 50·19										
τ^6 & τ^7 Eridani	132	2 4·5	163 50·50	0·32	·01	...	163 50·17	2″·33									
	133	2 7·0	163 57·00	−0·32	−·01	...	163 56·67										
App. index error ...																	
XXIII.	135 bis	23 29·1	57 39·75	+0·04	−·16	...	57 39·63	2′·68									
Dec. 4, 1874	136 „	23 31·3	57 34·38	0·04	·16	...	57 34·26										
ξ^1 & ξ^2 Can. Maj.	137 „	23 33·5	57 34·13	0·04	·16	...	57 34·01	2″·42									
	138 „	23 36·0	57 39·50	+0·03	−·16	...	57 39·37										
App. index error ...																	
XXIV.	134	22 24·6	129 26·75	−0·24	−·21	...	129 26·30	3′·50									
Dec. 4, 1874	135	22 26·6	129 18·75	0·23	·21	...	129 18·31										
P. A. stars, γ & δ	136	22 28·8	129 19·00	0·22	·21	...	129 18·57	2″·46									
	137	22 32·2	129 25·00	−0·21	−·21	...	129 24·58										
App. index error ...																	

Distance not observed

Distance not observed

Distance not observed

No. of group — Date — Name of objects	Position Angles								Distances								
	Rotation number	Hour angle	Observed position angle	Refraction	Aberration, &c.	Proper motion	Sum	Values of ψ & μ	Rotation number	Hour angle	Sc. A − Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Mean	Aberration	Proper motion	Distance, 1874·0 in screw revolutions
		h. m.	° ′	′	′	′	° ′			h. m.	rev.	rev.	rev.	rev.	rev.	rev.	rev.
XXV. Dec. 4, 1874 *a* Piscium	138 bis	...	123 23·50	...	...	...	...	...	138	...	− 0·2493	...	...	0·2440	...	...	0·2440
	139 „	...	158 54·50	...	...	...	...		139	...	+ 0·2164	...	...				
	140 „	...	340 37·00	...	...	...	...	...	140	...	+ 0·2715	...	...				
	141 „	...	306 53·00	...	...	...	...		141	...	− 0·2387	...	...				
App. index error 1·8707																	
XXVI. Dec. 6, 1874 τ^6 & τ^7 Eridani	142	21 13·0	163 57·25	−0·44	−·01	...	163 56·80	3′·44	143	21 14·6	+ 93·6740	0·0261	93·7001	93·7007	−·0034	...	93·6973
	145	21 19·9	163 50·25	0·43	·01	...	163 49·81		144	21 19·0	− 93·6798	0·0261	93·7059				
	146*a*	21 22·2	163 50·25	0·42	·01	...	163 49·82	2″·41	146	21 23·6	− 93·6695	0·0260	93·6955				
	148	21 28·4	163 57·00	−0·40	−·01	...	163 56·59		147	21 26·0	+ 93·6753	0·0260	93·7013				
App. index error 1·8507																	
XXVII. Dec. 6, 1874 τ^6 & τ^7 Eridani	149	21 31·3	163 57·50	−0·40	−·01	...	163 57·09	3′·81	150	21 32·9	+ 93·6702	0·0260	93·6962	93·6930	−·0034	...	93·6896
	152	21 40·9	163 49·75	0·36	·01	...	163 49·38		151	21 36·7	− 93·6570	0·0260	93·6830				
	153	21 42·5	163 50·00	0·36	·01	...	163 49·63	2″·67	154	21 43·5	− 93·6770	0·0260	93·7030				
	156	21 48·6	163 57·50	−0·34	−·01	...	163 57·15		155	21 46·1	+ 93·6638	0·0260	93·6898				
App. index error 1·8514																	
XXVIII. Dec. 6, 1874 ξ^1 & ξ^2 Can. Maj.	157	19 8·7	57 38·50	+0·71	−·17	...	57 39·04	2′·65	158	19 6·9	+120·6720	0·1967	120·8687	120·8421	+·0035	...	120·8456
	160	19 18·1	57 33·50	0·55	·17	...	57 33·88		159	19 14·3	−120·6664	0·1720	120·8384				
	161	19 20·6	57 33·50	0·51	·17	...	57 33·84	2″·39	162	19 22·6	−120·6962	0·1496	120·8458				
	164	19 27·4	57 39·00	+0·43	−·17	...	57 39·26		163	19 25·3	−120·6719	0·1434	120·8153				
App. index error 1·8504																	
XXIX. Dec. 6, 1874 ξ^1 & ξ^2 Can. Maj.	165	19 34·3	57 38·75	+0·35	−·17	...	57 38·93	2′·39	Distance not observed								
	166	19 39·0	57 34·50	0·30	·17	...	57 34·63										
	167	19 42·0	57 34·00	0·27	·17	...	57 34·10	2″·16									
	167*a*	19 43·7	57 39·25	+0·26	−·17	...	57 39·34										
App. index error ...																	
XXX. Dec. 6, 1874 P. A. stars, γ & δ	168	18 24·8	129 31·25	−9·00	−·21	...	129 22·04	3′·77	Distance not observed								
	169	18 27·1	129 23·50	8·42	·21	...	129 14·87										
	170	18 29·3	129 23·25	7·93	·21	...	129 15·11	2″·64									
	170 bis	18 31·3	129 30·75	−7·55	−·21	...	129 22·99										
App. index error ...																	
XXXI. Dec. 6, 1874 P. A. stars, γ & δ	171	18 34·0	129 29·75	−7·06	−·21	...	129 22·48	2′·92	Distance not observed								
	172	18 35·6	129 22·50	6·77	·21	...	129 15·52										
	173	18 37·2	129 22·50	6·48	·21	...	129 15·81	2″·05									
	174	18 40·8	129 26·75	−6·00	−·21	...	129 20·54										
App. index error ...																	
XXXII. Dec. 13, 1874 Perseus zone, *c*–*e*	175	21 34·7	56 37·25	−0·67	−·38	+·11	56 36·31	1′·13	176	21 37·7	+197·6961	0·3201	198·0162	198·0334	−·0088	+·0024	198·0270
	178	21 45·6	56 35·13	0·74	·38	·11	56 34·12		177	21 40·0	−197·7199	0·3118	198·0317				
	...	...	...	...	...	...	...	1″·67	179	21 48·7	−197·7700	0·2827	198·0527				
	181	21 55·3	56 37·50	−0·80	−·38	+·11	56 36·43		180	21 53·8	+197·7668	0·2663	198·0331				
App. index error 1·8515																	

No. of group — Date — Name of objects	Position Angles								Distances									
	Rotation number	Hour angle	Observed position angle	Refraction	Aberration, &c.	Proper motion	Sum	Values of ψ & μ	Rotation number	Hour angle	Sc. A − Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Mean	Aberration	Proper motion	Distance, 1874·0 in screw revolutions
		h. m.	° ′	′	′	′	° ′	″		h. m.	rev.	rev.	rev.	rev.	rev.	rev.	rev.
XXXIII. Dec. 13, 1874 Perseus zone, *c–e*	182	22 2·8	56 36·75	−0·83	−·38	+·11	56 35·65	1″·26	183	22 5·9	+197·8056	0·2363	198·0419	198·0386	−·0088	+·0024	198·0322
	185	22 12·9	56 34·50	0·88	·38	·11	56 33·35		184	22 10·4	−197·8229	0·2263	198·0492				
	...	...	...	...	...	...	...	1″·86	186	22 15·5	−197·8091	0·2154	198·0245				
	188	22 22·3	56 37·25	−0·92	−·38	+·11	56 36·06		187	22 19·2	+197·8304	0·2083	198·0387				
App. index error 1·8515																	
XXXIV. Dec. 13, 1874 Perseus zone, *b–c*	189	22 33·3	46 29·63	−0·68	−·36	−·06	46 28·53	2″·35	190	22 36·8	+104·2161	0·1120	104·3281	104·3273	−·0044	+·0002	104·3231
	192	22 41·8	46 25·25	0·77	·36	·06	46 24·06		191	22 40·2	−104·2193	0·1094	104·3287				
	...	...	...	...	...	...	...	1″·84	193	22 43·1	−104·2279	0·1068	104·3347				
	195	22 50·9	46 30·25	−0·84	−·36	−·06	46 28·99		194	22 45·9	+104·2131	0·1046	104·3177				
App. index error 1·8515																	
XXXV. Dec. 13, 1874 Perseus zone, *b–c*	196	22 58·7	46 30·25	−0·91	−·36	−·06	46 28·92	2″·88	197	22 59·1	+104·2340	0·0957	104·3297	104·3305	−·0044	+·0002	104·3263
	199	23 6·1	46 25·00	0·97	·36	·06	46 23·61		198	23 4·1	−104·2467	0·0923	104·3390				
	...	...	...	...	...	...	...	2″·25	200	23 9·5	−104·2334	0·0889	104·3223				
	202	23 14·2	46 31·25	−1·02	−·36	−·06	46 29·81		201	23 11·9	+104·2432	0·0878	104·3310				
App. index error 1·8515																	
XXXVI. Dec. 13, 1874 Perseus zone, *e–g*	203	23 23·4	80 8·50	−0·60	−·32	−·06	80 7·52	1′·08	204	23 35·0	+196·6615	0·0645	196·7260	196·7289	−·0091	−·0043	196·7155
	206	23 30·9	80 6·00	0·56	·32	·06	80 5·06		205	23 38·5	−196·6668	0·0633	196·7301				
	...	...	...	...	...	...	...	1″·59	207	23 42·3	−196·6586	0·0618	196·7204				
	209	23 48·8	80 7·75	−0·46	−·32	−·06	80 6·91		208	23 45·8	+196·6784	0·0607	196·7391				
App. index error 1·8515																	
XXXVII. Dec. 13, 1874 Perseus zone, *e–g*	210	23 55·2	80 8·25	−0·43	−·32	−·06	80 7·44	1′·56	211	23 58·5	+196·6848	0·0569	196·7417	196·7368	−·0091	−·0043	196·7234
	213	0 4·3	80 5·00	0·38	·32	·06	80 4·24		212	0 2·0	−196·6785	0·0562	196·7347				
	...	...	...	...	...	...	...	2″·30	214	0 6·7	−196·0578	0·0554	196·7132				
	216	0 12·8	80 8·00	−0·34	−·32	−·06	80 7·28		213	0 9·5	+196·7030	0·0547	196·7577				
App. index error 1·8515																	
XXXVIII. Dec. 13, 1874 Perseus zone, *h–k*	217	0 35·3	65 28·75	−0·78	−·33	−·05	65 27·59	1″·56	218	0 39·1	+188·1674	0·0577	188·2251	188·2235	−·0093	−·0021	188·2121
	220	0 52·0	65 25·25	0·72	·33	·05	65 24·15		219	0 47·2	−188·1417	0·0558	188·1975				
	...	...	...	...	...	...	...	2″·19	221	0 53·9	−188·1774	0·0547	188·2321				
	223	0 59·0	65 28·00	−0·69	−·33	−·05	65 26·93		222	0 56·7	+188·1852	0·0539	188·2391				
App. index error 1·8515																	
XXXIX. Dec. 13, 1874 Perseus zone, *h–k*	224	1 6·2	65 28·00	−0·67	−·33	−·05	65 26·95	1′·38	225	1 8·6	+188·1523	0·0517	188·2040	188·2074	−·0093	−·0021	188·1960
	227	1 14·2	65 25·00	0·63	·33	·05	65 23·99		226	1 12·1	−188·1514	0·0509	188·2023				
	...	...	...	...	...	...	...	1″·94	228	1 16·0	−188·1744	0·0509	188·2253				
	230	1 22·6	65 27·50	−0·59	−·33	−·05	65 26·53		229	1 20·6	+188·1476	0·0505	188·1981				
App. index error 1·8515																	
XL. Dec. 13, 1874 Perseus zone, *h–k*	231	22 10·5	65 28·00	−1·01	−·29	−·05	65 26·65	1″·25	232	22 13·9	+188·0285	0·1692	188·1977	188·2009	−·0096	−·0022	188·1891
	234	22 19·7	65 25·50	0·99	·29	·05	65 24·17		233	22 16·2	−188·0381	0·1633	188·2014				
	...	...	...	...	...	...	...	1″·76	235	22 20·7	−188·0529	0·1569	188·2098				
	237	22 26·7	65 28·00	−0·98	−·29	−·05	65 26·68		236	22 23·7	+188·0423	0·1525	188·1948				
App. index error 1·8515																	

No. of group — Date — Name of objects	Position Angles								Distances								
	Rotation number	Hour angle	Observed position angle	Refraction	Aberration, &c.	Proper motion	Sum	Values of ψ & μ	Rotation number	Hour angle	Sc. A − Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Mean	Aberration	Proper motion	Distance, 1874·0 in screw revolutions
		h. m.	° ′	′	′	′	° ′			h. m.	rev.	rev.	rev.	rev.	rev.	rev.	rev.
XLI. Dec. 14, 1874 Perseus zone, *h–k*	238	22 37·6	65 27·25	−0·97	−·29	−·05	65 25·94	1′·26	239	22 40·4	+188·0735	0·1305	188·2040	188·2177	−·0096	−·0022	188·2059
	241	22 44·8	65 25·25	0·97	·29	·05	65 23·94		240	22 43·3	−188·1085	0·1272	188·2357				
	…	…	…	…	…	…	…	1″·77	242	22 47·1	−188·1045	0·1227	188·2272				
	244	22 51·7	65 28·25	−0·96	−·29	−·05	65 26·95		243	22 49·2	+188·0829	0·1209	188·2038				
App. index error 1·8463																	
XLII. Dec. 14, 1874 Perseus zone, *g–h*	245	23 6·2	71 34·25	−0·89	−·31	+·08	71 33·13	2′·06	246	23 7·5	+124·8203	0·0611	124·8814	124·8881	−·0062	+·0014	124·8833
	248	23 12·7	71 29·75	0·86	·31	·08	71 28·66		247	23 9·8	−124·8270	0·0600	124·8870				
	…	…	…	…	…	…	…	1″·92	249	23 14·7	−124·8172	0·0581	124·8753				
	251	23 18·3	71 33·50	−0·85	−·31	+·08	71 32·42		250	23 17·0	+124·8516	0·0570	124·9086				
App. index error 1·8463																	
XLIII. Dec. 14, 1874 Perseus zone, *g–h*	252	23 35·4	71 34·00	−0·79	−·31	+·08	71 32·98	2′·07	253	23 39·0	+124·8319	0·0483	124·8802	124·8889	−·0062	+·0014	124·8841
	255	23 44·7	71 30·00	0·76	·31	·08	71 29·01		254	23 42·5	−124·8608	0·0461	124·9069				
	…	…	…	…	…	…	…	1″·93	256	23 46·4	−124·8342	0·0456	124·8798				
	258	23 52·6	71 34·25	−0·73	−·31	+·08	71 33·29		257	23 49·7	+124·8436	0·0449	124·8885				
App. index error 1·8463																	
XLIV. Dec. 14, 1874 Perseus zone, *c–e*	259	23 57·6	56 38·25	−1·15	−·34	+·11	56 36·87	1′·31	260	0 0·4	+197·9358	0·0970	198·0328	198·0347	−·0090	+·0024	198·0281
	262	0 6·6	56 35·25	1·15	·34	·11	56 33·87		261	0 3·1	−197·9478	0·0955	198·0433				
	…	…	…	…	…	…	…	1″·94	263	0 8·9	−197·9361	0·0921	198·0282				
	265	0 15·2	56 37·50	−1·16	−·34	+·11	56 36·11		264	0 12·0	+197·9441	0·0902	198·0343				
App. index error 1·8463																	
XLV. Dec. 14, 1874 Perseus zone, *c–e*	266	0 20·4	56 37·50	−1·16	−·34	+·11	56 36·11	1′·13	267	0 21·6	+197·9682	0·0849	198·0531	198·0315	−·0090	+·0024	198·0249
	269	0 27·9	56 35·75	1·16	·34	·11	56 34·36		268	0 24·1	−197·9251	0·0834	198·0085				
	…	…	…	…	…	…	…	1″·67	270	0 31·1	−197·9402	0·0800	198·0202				
	272	0 38·2	56 38·50	−1·16	−·34	+·11	56 37·11		271	0 34·8	+197·9657	0·0785	198·0442				
App. index error 1·8463																	
XLVI. Dec. 14, 1874 Hydra zone, *e–f*	273	20 23·8	173 35·25	+0·72	+·25	−·26	173 35·96	1′·76	274	20 25·6	+ 74·0085	0·0249	74·0334	74·0507	+·0049	−·0004	74·0552
	276	20 30·0	173 38·00	0·66	·25	·26	173 38·65		275	20 28·1	− 74·0281	0·0248	74·0529				
	…	…	…	…	…	…	…	0″·98	277	20 33·5	− 74·0297	0·0246	74·0543				
	279	20 38·5	173 37·25	+0·59	+·25	−·26	173 37·83		278	20 35·7	+ 74·0378	0·0245	74·0623				
App. index error 1·8512																	
XLVII. Dec. 14, 1874 Hydra zone, *e–f*	280	20 45·2	173 38·00	+0·56	+·25	−·26	173 38·55	0′·35	281	20 47·7	+ 74·0241	0·0241	74·0482	74·0466	+·0049	−·0004	74·0511
	283	20 53·2	173 38·25	0·49	·25	·26	173 38·73		282	20 50·4	− 74·0228	0·0240	74·0468				
	…	…	…	…	…	…	…	0″·19	284	20 54·8	− 74·0168	0·0239	74·0407				
	286	20 59·7	173 37·75	+0·47	+·25	−·26	173 38·21		285	21 1·4	+ 74·0269	0·0237	74·0506				
App. index error 1·8512																	
XLVIII. Dec. 16, 1874 Perseus zone, *e–g*	287	0 5·8	80 9·25	−0·38	−·32	−·06	80 8·49	1′·75	288	0 9·1	+196·6945	0·0551	196·7496	196·7513	−·0099	−·0044	196·7370
	290	0 15·0	80 5·75	0·33	·32	·06	80 5·04		289	0 12·2	−196·6995	0·0547	196·7542				
	…	…	…	…	…	…	…	2″·58	291	0 16·9	−196·6944	0·0540	196·7484				
	293	0 23·7	80 9·25	−0·28	−·32	−·06	80 8·59		292	0 20·2	+196·6994	0·0536	196·7530				
App. index error 1·8475																	

No. of group — Date — Name of objects	Position Angles								Distances								
	Rotation number	Hour angle	Observed position angle	Refraction	Aberration, &c.	Proper motion	Sum	Values of ψ & μ	Rotation number	Hour angle	Sc. A − Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Mean	Aberration	Proper motion	Distance, 1874·0 in screw revolutions
		h. m.	° ′	′	′	′	° ′	′		h. m.	rev.	rev.	rev.	rev.	rev.	rev.	rev.
XLIX. Dec. 16, 1874 Hydra zone, *d–e*	294	19 10·5	149 56·50	−1·47	−·31	+·19	149 54·91	2′·41	295	19 13·7	+120·4678	0·0373	120·5051	120·5160	+·0077	−·0009	120·5228
	297	19 27·3	149 51·00	0·89	·31	·19	149 49·99		296	19 18·8	−120·4794	0·0369	120·5163				
	...	...	...	...	...	...	...	2″·17	298	19 29·0	−120·4829	0·0361	120·5190				
	300	19 34·6	149 55·50	−0·69	−·31	+·19	149 54·69		299	19 33·0	+120·4879	0·0356	120·5235				
App. index error 1·8552																	
L. Dec. 16, 1874 Hydra zone, *d–e*	301	19 41·2	149 55·25	−0·57	−·31	+·19	149 54·56	2′·41	302	19 42·7	+120·4767	0·0346	120·5113	120·5130	+·0077	−·0009	120·5198
	304	19 47·4	149 50·50	0·48	·31	·19	149 49·90		303	19 44·9	−120·4850	0·0344	120·5194				
	...	...	...	...	...	...	...	2″·18	305	19 50·1	−120·4691	0·0340	120·5031				
	307	20 2·6	149 55·25	−0·25	−·31	+·19	149 54·88		306	19 52·8	+120·4844	0·0338	120·5182				
App. index error 1·8552																	
LI. Dec. 21, 1874 Hydra zone, *c–d*	308	19 47·3	162 4·25	+0·35	−·31	−·29	162 4·00	3′·83	309	20 1·1	+ 85·3942	0·0233	85·4175	85·4057	+·0049	+·0008	85·4114
	311	20 22·9	161 57·00	0·26	·31	·29	161 56·66		310	20 19·8	− 85·3776	0·0234	85·4010				
	...	...	...	...	...	...	...	5″·87	312	20 26·2	− 85·3753	0·0235	85·4018				
	314	20 32·5	162 5·00	+0·24	−·31	−·29	162 4·64		313	20 29·3	+ 85·3788	0·0235	85·4023				
App. index error 1·8424																	
LII. Dec. 21, 1874 Hydra zone, *c–d*	315	20 45·9	162 5·75	+0·22	−·31	−·29	162 5·37	4′·26	316	20 50·8	+ 85·3729	0·0236	85·3965	85·4023	+·0049	+·0008	85·4080
	318	21 14·8	161 57·25	0·20	·31	·29	161 56·85		317	21 11·7	− 85·3837	0·0238	85·4075				
	...	...	...	...	...	...	...	6″·52	319	21 16·4	− 85·3706	0·0238	85·3944				
	321	21 20·7	162 5·75	+0·19	−·31	−·29	162 5·34		320	21 18·5	+ 85·3869	0·0239	85·4108				
App. index error 1·8424																	
LIII. Dec. 21, 1874 Hydra zone, *b–c*	322	21 28·4	157 20·00	+0·11	−·31	+·14	157 19·94	4′·44	323	21 29·9	+ 82·3148	0·0225	82·3373	82·3464	+·0047	+·0005	82·3516
	325	21 35·3	157 12·00	0·11	·31	·14	157 11·94		324	21 32·4	− 82·3285	0·0225	82·3510				
	...	...	...	...	...	...	...	2″·74	326	21 37·0	− 82·3379	0·0225	82·3604				
	328	21 43·0	157 21·75	+0·12	−·31	+·14	157 21·70		327	21 40·6	+ 82·3144	0·0226	82·3370				
App. index error 1·8424																	
LIV. Dec. 21, 1874 Hydra zone, *b–c*	329	21 48·5	157 21·00	+0·12	−·31	+·14	157 20·95	3′·75	330	21 50·8	+ 82·3107	0·0227	82·3334	82·3212	+·0047	+·0005	82·3264
	332	21 53·8	157 13·75	0·12	·31	·14	157 13·70		331	21 53·0	− 82·2772	0·0227	82·2999				
	...	...	...	...	...	...	...	2″·31	333	21 58·0	− 82·3011	0·0227	82·3238				
	335	22 2·1	157 21·50	+0·12	−·31	+·14	157 21·45		334	22 0·6	+ 82·3048	0·0228	82·3276				
App. index error 1·8424																	
LV. Dec. 21, 1874 Hydra zone, *a–b*	336	22 9·3	171 26·75	+0·17	−·30	−·13	171 26·49	3′·82	337	22 12·0	+ 93·2333	0·0277	93·2610	93·2661	+·0054	−·0008	93·2707
	339	22 17·6	171 19·50	0·15	·30	·13	171 19·22		338	22 14·7	− 93·2294	0·0277	93·2571				
	...	...	...	...	...	...	...	2″·66	340	22 19·1	− 93·2394	0·0278	93·2672				
	342	22 26·5	171 27·50	+0·14	−·30	−·13	171 27·21		341	22 24·4	+ 93·2514	0·0278	93·2792				
App. index error 1·8424																	
LVI. Dec. 21, 1874 Hydra zone, *a–b*	343	22 31·3	171 26·50	+0·14	−·30	−·13	171 26·21	3′·50	344	22 32·9	+ 93·2185	0·0278	93·2463	93·2503	+·0054	−·0008	93·2549
	346	22 38·5	171 19·00	0·13	·30	·13	171 18·70		345	22 36·9	− 93·2346	0·0278	93·2624				
	...	...	...	...	...	...	...	2″·44	347	22 40·4	− 93·2294	0·0278	93·2572				
	349	22 44·8	171 25·50	+0·11	−·30	−·13	171 25·18		348	22 42·6	+ 93·2073	0·0278	93·2351				
App. index error 1·8424																	

No. of group — Date — Name of objects	Position Angles								Distances								
	Rotation number	Hour angle	Observed position angle	Refraction	Aberration, &c.	Proper motion	Sum	Values of ψ & μ	Rotation number	Hour angle	Sc. A − Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Mean	Aberration	Proper motion	Distance, 1874·0 in screw revolutions
		h. m.	° ′ ″	′	′	′	° ′ ″			h. m.	rev.	rev.	rev.	rev.	rev.	rev.	rev.
LVII. Dec. 22, 1874 Hydra zone, *d–f*	350	19 49·2	158 56′25	+0′20	−′32	+′11	158 56′24	1′·00	351	19 53·7	+190·5505	0·0506	190·6011	190·5943	+·0106	−·0001	190·6048
	353	19 58·2	158 54·75	0·20	·32	·11	158 54·74		352	19 56·1	−190·5390	0·0507	190·5897				
	...	...	...	...	...	...	...	1″·43	354	20 24·2	−190·5554	0·0513	190·6067				
	356	20 28·9	158 57·25	+0·19	−·32	+·11	158 57·23		355	20 26·6	+190·5281	0·0514	190·5795				
App. index error 1·8345																	
LVIII. Dec. 22, 1874 Hydra zone, *d–f*	357	20 35·7	158 55·50	+0·18	−·32	+·11	158 55·47	1′·75	358	20 37·8	+190·5414	0·0516	190·5930	190·6005	+·0106	−·0001	190·6110
	360	20 42·4	158 52·75	0·17	·32	·11	158 52·71		359	20 40·2	−190·5320	0·0516	190·5836				
	...	...	...	...	...	...	...	2″·50	361	20 44·4	−190·5579	0·0518	190·6097				
	363	20 50·3	158 57·00	+0·16	−·32	+·11	158 56·95		362	20 50·2	+190·5637	0·0518	190·6155				
App. index error 1·8345																	
LIX. Dec. 22, 1874 Hydra zone, *a–d*	364	21 11·1	168 2·50	+0·20	−·31	−·09	168 2·30	0′·82	365	21 15·6	Wrong stars observed						
	367	21 26·9	168 1·25	0·19	·31	·09	168 1·04		366	21 18·3							
	...	...	...	...	...	...	...	1″·59	368	21 24·9							
	370	21 30·8	168 3·25	+0·19	−·31	−·09	168 3·04		369	21 28·7							
App. index error ...																	
LX. Dec. 22, 1874 Hydra zone, *a–d*	371	21 52·3	168 2·75	+0·17	−·31	−·09	168 2·52	0′·88	372	21 55·6	Wrong stars observed						
	374	22 0·6	168 1·00	+0·16	−·31	−·09	168 0·76		373	21 58·8							
	...	...	...	...	...	...	...	1″·71	375	22 4·3							
	...	...	...	...	...	...	...		376	22 12·3							
App. index error ...																	
LXI. Dec. 23, 1874 Hydra zone, *a–c*	377	19 58·6	164 47·50	+0·40	−·31	−·07	164 47·52	0′·99	378	20 0·6	+174·1923	0·0488	174·2411	174·2455	+·0096	+·0007	174·2558
	380	20 4·6	164 45·50	0·39	·31	·07	164 45·51		379	20 3·0	−174·1958	0·0488	174·2446				
	...	...	...	...	...	...	...	1″·29	381	20 7·2	−174·1831	0·0488	174·2319				
	383	20 17·6	164 47·50	+0·34	−·31	−·07	164 47·46		382	20 9·7	+174·2156	0·0488	174·2644				
App. index error 1·8384																	
LXII. Dec. 23, 1874 Hydra zone, *a–c*									385	20 23·9	+174·1885	0·0488	174·2373	174·2512	+·0096	+·0007	174·2615
									386	20 27·9	−174·1960	0·0488	174·2448				
									388	20 31·5	−174·2235	0·0488	174·2723				
									389	20 34·0	+174·2017	0·0488	174·2505				
App. index error 1·8384																	
LXIII. Dec. 24, 1874 Hydra zone, *c–f*	391	1 29·9	159 55·0	−0·05	−·32	−·01	159 54·62	1′·00	392	1 34·7	+275·8560	0·0967	275·9527	275·9303	+·0146	+·0012	275·9461
	394	1 41·8	159 53·0	0·08	·32	·01	159 52·59		393	1 38·7	−275·8264	0·0975	275·9239				
	...	...	...	...	...	...	...	2″·07	395	1 43·4	−275·8380	0·0986	275·9366				
	397	2 16·5	159 55·0	−0·13	−·32	−·01	159 54·54		396	1 48·2	+275·8081	0·0997	275·9078				
App. index error 1·8529																	
LXIV. Dec. 26, 1874 Hydra zone, *c–f*	399	19 11·0	159 53·5	+0·29	−·32	−·01	159 53·46	1′·38	400	19 13·5	+275·8655	0·0709	275·9364	275·9908	+·0138	+·0012	276·0058
	402	19 24·4	159 50·5	0·28	·32	·01	159 50·45		401	19 23·0	−275·9217	0·0717	275·9934				
	...	...	...	...	...	...	...	2″·84	403	19 27·8	−275·9630	0·0721	276·0351				
	404 bis	19 36·4	159 53·0	+0·26	−·32	−·01	159 52·93		404	19 33·1	+275·9259	0·0724	275·9983				
App. index error 1·8885																	

No. of group — Date — Name of objects	Position Angles								Distances								
	Rotation number	Hour angle	Observed position angle	Refraction	Aberration, &c.	Proper motion	Sum	Values of ψ & μ	Rotation number	Hour angle	Sc. A−Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Mean	Aberration	Proper motion	Distance, 1874·0 in screw revolutions
		h. m.	° ′	′	′	′	° ′			h. m.	rev.	rev.	rev.	rev.	rev.	rev.	rev.
LXV. Dec. 26, 1874 Hydra zone, *c–f*	405	19 39·7	159 55·0	+0·25	−·32	−·01	159 54·92	1′·88	406	19 41·2	+275·9207	0·0728	275·9935	275·9950	+·0138	+·0012	276·0100
	408	19 49·1	159 50·5	0·25	·32	·01	159 50·42		407	19 46·0	−275·9163	0·0731	275·9894				
	...	...	...	...	...	...	...	3″·87	409	19 50·5	−275·9153	0·0733	275·9886				
	411	19 56·1	159 53·5	+0·25	−·32	−·01	159 53·42		410	19 54·0	+275·9352	0·0734	276·0086				
App. index error 1·8885																	
LXVI. Dec. 26, 1874 Hydra zone, *a–d*	412	20 6·5	163 54·0	+0·36	−·31	−·10	163 53·95	1′·64	413	20 9·4	+259·5852	0·0720	259·6572	259·6435	+·0132	+·0013	259·6580
	415*	20 19·4	163 50·5	0·31	·31	·10	163 50·40		414	20 14·3	−259·5637	0·0720	259·6357				
	...	...	...	...	...	...	...	3″·18	416	20 20·1	−259·5724	0·0721	259·6445				
	418*	20 24·9	163 53·5	+0·30	−·31	−·10	163 53·39		417	20 23·1	+259·5646	0·0721	259·6367				
App. index error 1·8885																	
LXVII. Dec. 26, 1874 Hydra zone, *a–d*	419	20 29·1	163 53·0	+0·30	−·31	−·10	163 52·89	1′·38	420	20 30·2	+259·5953	0·0722	258·6675	259·6429	+·0132	+·0013	259·6574
	422*	20 36·2	163 50·5	0·29	·31	·10	163 50·38		421	20 34·1	−259·5495	0·0722	260·6217				
	...	...	...	...	...	...	...	2″·68	423	20 39·3	−259·5601	0·0723	260·6324				
	425	20 44·7	163 53·5	+0·29	−·31	−·10	163 53·38		424	20 42·9	+259·5777	0·0723	258·6500				
App. index error 1·8885																	
LXVIII. Dec. 26, 1874 Hydra zone, *c–e*	425 bis	20 53·0	154 55·5	+0·08	−·32	·00	154 55·26	1′·38	426	20 54·6	+204·7621	0·0547	204·8168	204·8243	+·0103	+·0014	204·8360
	428	21 22·4	154 53·5	0·10	·32	·00	154 53·28		427	20 57·8	−204·7734	0·0547	204·8281				
	...	...	...	...	...	...	...	2″·11	429	21 23·2	−204·7693	0·0552	204·8245				
	431	21 28·6	154 57·0	+0·11	−·32	·00	154 56·79		430	21 26·9	+204·7723	0·0553	204·8276				
App. index error 1·8885																	
LXIX. Dec. 26, 1874 Hydra zone, *c–e*	432	20 31·9	154 56·5	+0·11	−·32	·00	154 56·29	1′·38	433	21 32·6	+204·7715	0·0554	204·8269	204·8164	+·0103	+·0014	204·8281
	435	20 38·8	154 53·5	0·11	·32	·00	154 53·29		434	21 36·0	−204·7716	0·0555	204·8271				
	...	...	...	...	...	...	...	2″·11	436	21 39·0	−204·7440	0·0555	204·7995				
	438	20 43·6	154 56·0	+0·11	−·32	·00	154 55·79		437	21 41·9	+204·7565	0·0556	204·8121				
App. index error 1·8885																	
LXX. Dec. 26, 1874 Hydra zone, *d–f*	Position angles not observed								440	21 51·3	+190·5708	0·0531	190·6239	190·6068	+·0096	−·0001	190·6163
									441	21 57·2	−190·5606	0·0532	190·6138				
									443	21 59·9	−190·5475	0·0533	190·6008				
									444	22 3·2	+190·5353	0·0534	190·5887				
App. index error 1·8885																	
LXXI. Dec. 26, 1874 Hydra zone, *d–f*	Position angles not observed								445	22 9·6	+190·5627	0·0536	190·6163	190·6267	+·0096	−·0001	190·6362
									446	22 17·3	−190·5664	0·0538	190·6202				
									447	22 21·5	−190·5753	0·0539	190·6292				
									448	22 27·3	+190·5871	0·0541	190·6412				
App. index error 1·8885																	

415 and 418. Position angle observed as 348°.

422. Position angle observed as 164°.

TABLE III.

OBSERVATIONS OF JUNO.

Group — Date — Objects	Position Angles					Distances									
	Rotation number	Time by chronometer	Position circle		Mean	Rotation number	Time by chronometer	Scale A				Scale B				Resulting value, Scale A − Scale B corrected for screw and division error
			Vernier I.	II.				Preceding div.		Following div.		Preceding div.		Following div.		
								Scale	Screw	Scale	Screw	Scale	Screw	Scale	Screw	
		h. m. s.	° ′	′	° ′		h. m. s.									
I. Nov. 10, 1874 Juno & ζ	1	23 14 50	259	35·5	259 35·5	2	23 14 50	117	0·300	116	2·314	32	1·032	31	3·033	+169·2947
	4	23 24 28	259	35·0	259 35·0	3	23 24 28	33	0·793	32	2·814	116	1·091	115	3·100	−166·2829
	4 bis	23 30 55	259	32·5	259 32·5	5	23 30 55	33	0·710	32	2·708	116	1·145	115	3·162	−166·4346
	7	23 41 7	259	30·0	259 30·0	6	23 41 7	117	0·600	116	2·628	32	0·659	31	2·675	+169·9650
II. Nov. 10, 1874 Juno & κ	8	0 4 58	101	55·0	101 55·0	9	0 4 58	17	1·499	16	3·499	131	1·375	130	3·370	−227·8741
	11	0 11 43	101	51·5	101 51·5	10	0 11 43	132	0·532	131	2·520	16	1·624	15	3·628	+230·9631
	11	0 11 43	101	51·5	101 51·5	12	0 7 35	132	0·473	131	2·470	16	1·672	15	3·680	+230·8590
	14	0 17 33	101	58·0	101 58·0	13	0 17 33	17	1·659	16	3·659	131	1·359	130	3·342	−227·6925
III. Nov. 10, 1874 Juno & κ	15	0 27 43	101 58·0	...	110 58·0	16	0 27 43	18	0·112	17	2·127	131	1·639	130	3·633	−227·5122
	18	0 32 1	101 58·0	...	101 58·0	17	0 32 1	132	0·826	131	2·802	17	0·075	16	2·080	+230·7913
	18 bis	0 35 27	101 58·5	...	101 58·5	19	0 35 27	132	0·738	131	2·728	17	0·140	16	2·148	+230·6436
	21	0 40 40	102 2·5	...	102 2·5	20	0 40 40	18	0·168	17	2·178	131	1·506	130	3·518	−227·3354
IV. Nov. 10, 1874 Juno & ζ	22	1 2 23	259 12·5	...	259 12·5	23	1 2 23	117	1·940	116	3·940	31	1·390	30	3·390	+172·5617
	25	1 6 29	259 13·0	...	259 13·0	24	1 6 29	32	1·233	31	3·243	116	1·680	115	3·662	−168·4192
V. Nov. 10, 1874 Juno & ζ	26	6 52 50	258 14·0	...	258 14·0	27	6 55 20	30	1·635	29	3·625	118	1·036	117	3·040	−175·4080
	29	6 59 30	258 11·5	...	258 11·5	28	7 1 23	119	0·460	118	2·459	29	1·608	28	3·600	+178·8831
	29 bis	7 4 25	258 10·0	...	258 10·0	30	7 6 40	119	2·465	118	2·475	29	1·625	28	3·632	+178·8690
	32	7 10 30	258 9·5	...	258 9·5	31	7 9 50	30	1·408	29	3·419	118	1·236	117	3·226	−175·8165
VI. Nov. 10, 1874 Juno & κ	33	7 19 17	103	34·0	103 34·0	34	7 20 41	19	1·401	18	3·397	130	0·536	129	2·518	−221·1359
	36	7 31 15	103	34·5	103 34·5	35	7 27 15	130	1·658	129	3·650	18	1·489	17	3·475	+224·2254
	36	7 31 15	103	34·5	103 34·5	37	7 32 27	130	1·664	129	3·653	18	1·480	17	3·498	+224·2228
	39	7 41 10	103	38·0	103 38·0	38	7 36 20	19	1·635	18	3·646	130	0·362	129	2·367	−220·7337
VII. Nov. 10, 1874 Juno & κ	40	7 44 5	103	37·5	103 37·5	Distance was not observed in this group										
	41	7 47 10	103	38·5	103 38·5											
VIII. Nov. 10, 1874 Juno & ζ	42	7 51 55	258 0·0	...	258 0·0	Distance was not observed in this group										
	43	7 57 10	258 0·0	...	258 0·0											

Group	Chron. corr.	Bar.	Ther.	Group	Chron. corr.	Bar.	Ther.
	m. s.	in.	°		m. s.	in.	°
I.	+0 20	30·15	78·0	V.	+0 20·5	30·15	71·5
II.	+0 20	30·15	76·0	VI.	+0 20·5	30·15	71·5
III.	+0 20	30·15	76·0	VII.	+0 20·5	30·15	71·5
IV.	+0 20	30·15	75·5	VIII.	+0 20·5	30·15	71·5

Group — Date — Objects	Position Angles: Rotation number	Time by chronometer	Position circle: Vernier I.	Position circle: II.	Mean	Distances: Rotation number	Time by chronometer	Scale A: Preceding div. Scale	Scale A: Preceding div. Screw	Scale A: Following div. Scale	Scale A: Following div. Screw	Scale B: Preceding div. Scale	Scale B: Preceding div. Screw	Scale B: Following div. Scale	Scale B: Following div. Screw	Resulting value, Scale A − Scale B corrected for screw and division error
		h. m. s.	° ′	′	° ′		h. m. s.									
IX. Nov. 11, 1874 Juno & *s*	44	22 22 48	255	44·0	255 44·0											
	47	22 31 27·5	255	45·0	255 45·5											
	47	22 31 27·5	255	45·0	255 45·5											
	50	22 45 23	255	40·5	255 40·5											
X. Nov. 12, 1874 Juno & *θ*	51	22 24 52	75 54·5	...	75 54·5	52	22 26 52	84	0·534	83	2·537	65	1·449	64	3·446	+37·1138
	54	22 33 2	75 59·5	...	75 59·5	53	22 30 16	66	1·139	65	3·149	83	0·948	82	2·940	−33·7748
	54 bis	22 41 2	76 6·0	...	76 6·0	55	22 43 43	66	1·254	65	3·243	83	0·800	82	2·800	−33·5253
	57	22 50 49	76 11·0	...	76 11·0	56	22 48 18	84	0·270	83	2·275	65	1·649	64	3·648	+36·6529
XI. Nov. 12, 1874 Juno & *θ*	58	22 57 24	76 12·5	...	76 12·5	59	22 58 29	84	0·191	83	2·198	65	1·751	64	3·738	+36·4773
	61	23 5 25	76 26·0	...	76 26·0	60	23 2 34	66	1·430	65	3·435	83	0·606	82	2·89	−33·1371
	61 bis	23 6 35	76 23·0	...	76 23·0	62	23 10 10	66	1·507	65	3·507	83	0·533	82	2·530	−32·9998
	64	23 17 44	76 30·0	...	76 30·0	63	23 13 25	84	0·037	83	2·030	65	1·850	64	3·835	+36·2169
XII. Nov. 12, 1874 Juno & *θ*	65	23 27 14	76	35·5	76 35·5	66	23 29 43	83	1·298	82	3·300	65	1·489	64	3·501	+35·8304
	68	23 38 33	76	46·0	76 46·0	67	23 34 8	66	1·180	65	3·190	82	1·737	81	3·729	−32·5242
	68 bis	23 40 37	76	50·5	76 50·5	69	23 42 15	66	1·278	65	3·272	82	1·647	81	3·640	−32·3458
	71	23 49 27	76	48·0	76 48·0	70	23 46 42	83	1·172	82	3·160	65	1·660	64	3·651	+35·5386
XIII. Nov. 12, 1874 Juno & *θ*	72	23 58 15	76 55·0	...	76 55·0	73	23 59 42	83	1·541	82	3·528	66	0·272	65	2·280	+35·2795
	75	0 9 20	77 15·0	...	77 15·0	74	0 4 29	67	0·004	66	2·016	82	1·909	81	3·907	−31·8751
XIV. Nov. 12, 1874 Juno & *θ*	76	5 14 59	81 55·0	...	81 55·0	77	5 16 36	81	1·259	80	3·255	67	0·314	66	2·324	+28·9676
	79	5 24 41	82 2·5	...	82 2·5	78	5 21 39	68	1·041	67	3·026	81	0·684	80	2·680	−25·6208
	79 bis	5 28 45	82 12·5	...	82 12·5	80	5 30 51	68	1·138	67	3·135	81	0·560	80	2·565	−25·3978
	82	5 41 7	82 14·5	...	82 14·5	81	5 33 35	81	1·121	80	3·104	67	0·524	66	2·521	+28·6216
XV. Nov. 12, 1874 Juno & *θ*	83	5 50 45	82	35·0	82 35·0	84	5 53 8	81	1·543	80	3·530	67	1·322	66	3·305	+28·2492
	86	6 3 15	82	47·5	82 47·5	85	5 56 56	68	0·952	67	2·961	80	1·912	79	3·902	−24·9281
	86 bis	6 4 53	82	56·0	82 56·0	87	6 9 5	68	1·075	67	3·073	80	1·785	79	3·760	−24·6721
	89	6 17 56	83	8·0	83 8·0	88	6 13 18	81	1·280	80	3·274	67	1·471	66	3·473	+27·8334
XVI. Nov. 12, 1874 Juno & *θ*	90	6 26 55	83	15·5	83 15·5	91	6 28 20	81	1·139	80	3·140	67	1·618	66	3·595	+27·5627
	93	6 35 51	83	29·5	83 29·5	92	6 33 10	68	1·279	67	3·273	80	1·523	79	3·530	−24·2244
	93	6 35 51	83	29·5	83 29·5	94	6 37 48	68	1·334	67	3·335	80	1·470	79	3·460	−24·1055
	96	6 45 0	83	36·5	83 36·5	95	6 42 25	81	0·970	80	2·990	67	1·711	66	3·700	+27·3026

Group	Chron. corr.	Bar.	Ther.	Group	Chron. corr.	Bar.	Ther.
	m. s.	in.	°		m. s.	in.	°
IX.	+0 22	30·15	73·5	XIII.	+0 24	30·12	70·6
X.	+0 24	30·10	72·5	XIV.	+0 24·5	30·12	66·0
XI.	+0 24	30·10	72·5	XV.	+0 24·5	30·12	66·0
XII.	+0 24	30·10	72·0	XVI.	+0 25	30·12	65·4

Group — Date — Objects	Position Angles: Rotation number	Time by chronometer	Position circle: Vernier I.	Position circle: II.	Mean	Distances: Rotation number	Time by chronometer	Scale A: Preceding div. Scale	Scale A: Preceding div. Screw	Scale A: Following div. Scale	Scale A: Following div. Screw	Scale B: Preceding div. Scale	Scale B: Preceding div. Screw	Scale B: Following div. Scale	Scale B: Following div. Screw	Resulting value, Scale A − Scale B corrected for screw and division error
		h. m. s.	° ′	′	° ′		h. m. s.									
XVII. Nov. 12, 1874 Juno & θ	97	6 54 26	83 53·0	...	83 53·0	98	6 55 41·5	81	1·389	80	3·386	68	0·387	67	2·388	+27·0310
	100	7 2 46	84 9·5	...	84 9·5	99	6 59 55	69	0·070	68	2·073	80	1·818	79	3·806	−23·7137
	100 bis	7 5 55	84 9·0	...	84 9·0	101	7 7 9	69	0·127	68	2·130	80	1·719	79	3·720	−23·5630
	103	7 14 47	84 17·5	...	84 17·5	102	7 11 28	81	1·279	80	3·263	68	0·564	67	2·555	+26·7439
XVIII. Nov. 13, 1874 Juno & θ	104	22 12 26	126 52·0	...	126 52·0	105	22 15 15·5	78	1·230	77	3·237	71	0·659	70	2·658	+14·6049
	107	22 22 50	127 31·0	...	127 31·0	106	22 19 53	72	0·292	71	2·286	77	1·591	76	3·590	−11·2684
	107 bis	22 24 6	127 47·0	...	127 47·0	108	22 25 53·5	72	0·319	71	2·319	77	1·576	76	3·573	−11·2229
	110	22 31 45	128 18·0	...	128 18·0	109	22 28 45	78	1·146	77	3·135	71	0·660	70	2·666	+14·5079
XIX. Nov. 13, 1874 Juno & θ	111	22 41 58	129	20·0	129 20·0	112	22 42 58	78	0·765	77	2·765	71	0·368	70	2·350	+14·4327
	114	22 48 20	129	43·5	129 43·5	113	22 45 30	72	0·033	71	2·032	77	1·190	76	3·193	−11·1270
	114 bis	22 49 16	129	55·5	129 55·5	115	22 50 30	72	0·063	71	2·060	77	1·170	76	3·170	−11·0763
	117	22 55 40·5	130	28·0	130 28·0	116	22 52 40	78	0·756	77	2·775	71	0·425	70	2·418	+14·3713
XX. Nov. 13, 1874 Juno & θ	118	23 4 41	131	9·0	131 9·0	119	23 6 15	78	0·735	77	2·745	71	0·489	70	2·505	+14·2691
	121	23 11 17	131	47·0	131 47·0	120	23 9 7	72	0·141	71	2·136	77	1·152	76	3·142	−10·9753
	121 bis	23 13 0·5	132	6·0	132 6·0	122	23 14 10·5	72	0·172	71	2·175	77	1·154	76	3·149	−10·9449
	124	23 21 58·5	132	52·0	132 52·0	123	23 18 43·5	78	0·745	77	2·755	71	0·564	70	2·565	+14·2119
XXI. Nov. 13, 1874 Juno & θ	125	23 37 40·5	134 12·5	...	134 12·5	126	23 39 9	78	0·875	77	2·860	71	0·795	70	2·788	+14·1038
	128	23 46 10	135 14·0	...	135 14·0	127	23 42 13	72	0·430	71	2·422	77	1·255	76	3·259	−10·8030
	128 bis	23 47 13	135 14·5	...	135 14·5	129	23 48 28	72	0·458	71	2·466	77	1·259	76	3·235	−10·7574
	131	23 54 53	135 51·5	...	135 51·5	130	23 51 18·5	78	0·826	77	2·835	71	0·800	70	2·809	+14·0532
XXII. Nov. 13, 1874 Juno & θ	132	5 59 20	170	56·5	170 56·5	133	6 2 6·5	78	1·090	77	3·100	71	0·408	70	2·402	+14·7190
	135	6 13 34	172	3·0	172 3·0	134	6 7 4	71	1·986	70	3·975	77	1·541	76	3·534	−11 5211
	135 bis	6 16 10	172	10·0	172 10·0	136	6 17 6·5	71	1·965	70	3·955	77	1·597	76	3·599	−11·6023
	138	6 24 9·5	173	6·0	173 6·0	137	6 20 2·5	78	1·195	77	3·196	71	0·309	70	2·315	+14·9111
XXIII. Nov. 13, 1874 Juno & θ	139	6 35 12	173 50·0	...	173 50·0	140	6 36 25	78	1·022	77	3·040	70	1·997	69	3·985	+15·0640
	142	6 42 31	174 5·0	...	174 5·0	141	6 40 9	71	1·616	70	3·612	77	1·482	76	3·491	−11·8395
	142 bis	6 45 1	174 31·5	...	174 31·5	143	7 2 53	71	1·541	70	3·550	77	1·560	76	3·553	−11·9772
	145	7 10 41	176 41·0	...	176 41·0	144	7 6 55	78	1·199	77	3·178	70	1·876	69	3·864	+15·3450
XXIV. Nov. 13, 1874 Juno & θ	146	7 25 38	177 33·0	...	177 33·0	147	7 27 25·5	78	1·280	77	3·288	70	1·770	69	3·770	+15·5427
	149	7 34 31·5	178 12·5	...	178 12·5	148	7 30 25	71	1·365	70	3·377	77	1·690	76	3·680	−12·2761
	150*a*	7 56 4·5	179 28·5	...	179 28·5	150	7 57 40	71	1·247	70	3·253	77	1·855	76	3·853	−12·5640
	152	8 2 9·5	180 33·5	...	180 33·5	151	7 59 35	78	1·510	77	3·482	70	1·588	69	3·602	+15·9261

Group	Chron. corr.	Bar.	Ther.	Group.	Chron. corr.	Bar.	Ther.
	m. s.	in.	°		m. s.	in.	°
XVII.	+0 25	30·07	65·0	XXI.	+0 26	30·14	74·6
XVIII.	+0 26	30·14	75·3	XXII.	+0 27	30·14	69·3
XIX.	+0 26	30·14	74·9	XXIII.	+0 27	30·14	69·3
XX.	+0 26	30·14	74·9	XXIV.	+0 27	30·14	69·2

Group — Date — Objects	Position Angles					Distances										
	Rotation number	Time by chronometer	Position circle		Mean	Rotation number	Time by chronometer	Scale A				Scale B				Resulting value, Scale A − Scale B corrected for screw and division error
			Vernier I.	II.				Preceding div.		Following div.		Preceding div.		Following div.		
								Scale	Screw	Scale	Screw	Scale	Screw	Scale	Screw	
		h. m. s.	° ′	′	° ′		h. m. s.									
XXV. Nov. 13, 1874 Juno & θ	153	7 36 19	178	25·5	178 25·5	154	7 38 21	71	1·620	70	3·596	78	0·000	77	2·001	− 12·3513
	156	7 45 50	179	16·5	179 16·5	155	7 42 36	78	1·638	77	3·611	70	1·905	69	3·891	+ 15·7536
	156	7 45 50	179	16·5	179 16·5	157	7 47 8·5	78	1·614	77	3·605	70	1·889	69	3·890	+ 15·7473
	159	7 54 8	179	31·5	179 31·5	158	7 51 57	71	1·523	70	3·500	78	0·080	77	2·067	− 12·5223
XXVI. Nov. 14, 1874 Juno & λ	160	6 53 39	...	...	...	161	7 2 36	119	0·290	118	2·310	30	0·932	29	2·945	+ 117·3873
	163	7 12 31	104	29·5	104 29·5	162	7 7 33	31	0·900	30	2·905	118	0·905	117	2·921	− 174·0025
	163 bis	7 14 7	104	31·0	104 31·0	164	7 18 32·5	31	1·004	30	2·998	118	0·854	117	2·869	− 173·8502
	166	7 27 25	104	39·0	104 39·0	165	7 23 46	119	0·088	118	2·110	30	1·108	29	3·109	+ 177·0163
XXVII. Nov. 14, 1874 Juno & ζ	167	7 35 19	311	33·5	311 33·5	168	7 36 56	119	0·725	118	2·739	29	1·220	28	3·213	+ 179·5383
	170	7 48 8	311	25·5	311 25·5	169	7 42 53	30	1·080	29	3·074	118	1·427	117	3·420	− 176·3405
	170	7 48 8	311	25·5	311 25·5	171*a*	7 54 37	30	1·090	29	3·093	118	1·391	117	3·393	− 176·2946
	173	8 3 39	311	25·0	311 25·0	172	8 0 8	119	0·740	118	2·740	29	1·140	28	3·145	+ 179·6198
XXVIII. Nov. 15, 1874 Juno & ζ	176	23 49 6·5	305	57·5	305 57·5	177	23 50 14	121	0·258	120	2·252	28	0·700	27	2·707	+ 185·5806
	179	23 55 24·5	305	56·7	305 56·7	178	23 53 16	29	0·630	28	2·620	120	0·980	119	2·989	− 182·3567
	180	23 57 16·5	305	55·5	305 55·5	181	23 58 26·5	29	0·589	28	2·580	120	1·011	119	3·025	− 182·4309
	183	0 6 24·5	305	52·0	305 52·0	182	0 1 43	121	0·313	120	2·307	28	0·618	27	2·624	+ 185·7169
XXIX. Nov. 15, 1874 Juno & λ	184	0 15 37	109	29·0	109 29·0	185	0 17 30	115	1·554	114	3·541	33	0·918	32	2·916	+ 164·6407
	187	0 23 40	109	34·5	109 34·5	186	0 20 50·5	34	0·872	33	2·876	115	0·190	114	2·191	− 161·3042
	187 bis	0 25 22	109	34·5	109 34·5	188	0 31 27	34	0·971	33	2·970	115	0·120	114	2·120	− 161·1360
	190	0 39 26	109	37·5	109 37·5	189	0 36 6·5	115	1·425	114	3·452	33	1·080	32	3·082	+ 164·3657
XXX. Nov. 15, 1874 Juno & λ	191	0 44 29·5	109 38·5	...	109 38·5	192	0 46 7	115	1·650	114	3·648	33	1·408	32	3·398	+ 164·2551
	194	0 54 18	109 44·5	...	109 44·5	193	0 50 57	34	1·325	33	3·335	115	0·250	114	2·245	− 160·9028
	194 bis	0 55 37·5	109 45·0	...	109 45·0	195	0 56 42	34	1·351	33	3·370	115	0·210	114	2·228	− 160·8446
	197	1 3 34·5	109 45·0	...	109 45·0	196	0 59 38	115	1·546	114	3·541	33	1·483	32	3·469	+ 164·0774
XXXI. Nov. 15, 1874 Juno & ζ	198	1 8 57·5	305 30·0	...	305 30·0	199	1 9 55	121	0·419	120	2·402	28	0·173	27	2·170	+ 186·2634
	201	1 16 50	305 28·5	...	305 28·5	200	1 13 34·5	29	0·108	28	2·085	120	1·098	119	3·120	− 183·0147
	201	1 16 50	305 28·5	...	305 28·5	202	1 17 59	29	0·100	28	2·089	120	1·175	119	3·169	− 183·0798
	204	1 24 28·5	305 25·0	...	305 25·0	203	1 21 45·5	121	0·504	120	2·480	28	0·126	27	2·100	+ 186·4038
XXXII. Nov. 15, 1874 Juno & ζ	205	5 25 49	304	3·0	304 3·0	206	5 27 46·5	121	1·280	120	3·260	27	0·812	26	2·805	+ 188·4928
	208	5 35 2	304	3·5	304 3·5	207	5 31 21	28	0·715	27	2·720	120	1·990	119	3·995	− 185·2737
	209	5 37 9	304	3·0	304 3·0	210	5 38 57	28	0·695	27	2·683	120	2·036	119	4·020	− 185·3385
	212	5 46 45·5	303	59·5	303 59·5	211	5 43 9	121	1·330	120	3·331	27	0·725	26	2·721	+ 188·6384

Group	Chron. corr.	Bar.	Ther.	Group	Chron. corr.	Bar.	Ther.
	m. s.	in.	°		m. s.	in.	°
XXV.	+0 27	30·14	69·2	XXIX.	+0 31·5	30·19	74·5
XXVI.	+0 30	30·18	69·9	XXX.	+0 31·5	30·20	73·9
XXVII.	+0 30	30·18	68·9	XXXI.	+0 31·5	30·22	73·2
XXVIII.	+0 31·5	30·19	74·5	XXXII.	+0 32	30·16	68·8

Group — Date — Objects	Position Angles					Distances										
	Rotation number	Time by chronometer	Position circle		Mean	Rotation number	Time by chronometer	Scale A				Scale B				Resulting value, Scale A − Scale B corrected for screw and division error
			Vernier I.	II.				Preceding div.		Following div.		Preceding div.		Following div.		
								Scale	Screw	Scale	Screw	Scale	Screw	Scale	Screw	
		h. m. s.	° ′	′	° ′		h. m. s.									
XXXIII. Nov. 15, 1874 Juno & λ	213	5 53 30	111	22·5	111 22·5	214	5 55 10	114	1·690	113	3·701	34	1·505	33	3·495	+ 160·2089
	216	6 2 23	111	27·0	111 27·0	215	5 58 57	35	1·420	34	3·423	114	0·318	113	2·322	− 156·8826
	217	6 4 50	111	27·0	111 27·0	218	6 7 7	35	1·510	34	3·506	114	0·270	113	2·288	− 156·7606
	220	6 14 43	111	29·5	111 29·5	219	6 11 30	114	1·583	113	3·595	34	1·629	33	3·625	+ 159·9767
XXXIV. Nov. 15, 1874 Juno & λ	221	6 21 11	111 31·5	...	111 31·5	222	6 24 13·5	114	0·907	113	2·930	34	1·135	33	3·132	+ 159·7964
	224	6 30 40	111 36·0	...	111 36·0	223	6 27 36	35	1·047	34	3·056	113	1·571	112	3·565	− 156·5021
	225	6 33 15	111 36·0	...	111 36·0	226 bis	6 38 49	35	1·110	34	3·098	113	1·470	112	3·469	− 156·3512
	228	6 46 43	111 39·0	...	111 39·0	227	6 44 9·5	114	0·761	113	2·775	34	1·240	33	3·240	+ 159·5393
XXXV. Nov. 15, 1874 Juno & ζ	229	6 54 25	304 36·5	...	304 36·5	230	6 57 1	122	0·140	121	2·145	27	0·980	26	2·983	+ 189·1904
	232	7 4 28	304 35·5	...	304 35·5	231	7 1 24·5	28	0·920	27	2·916	121	0·873	120	2·880	− 185·9572
	233	7 8 17	304 35·5	...	304 35·5	234	7 9 42	28	0·895	27	2·900	121	0·895	120	2·913	− 186·0062
	236	7 18 32	304 30·0	...	304 30·0	235	7 14 50	122	0·223	121	2·220	27	0·920	26	2·934	+ 189·3241
XXXVI. Nov. 15, 1874 Juno & ζ	237	7 21 2	303 29·5	...	303 29·5	238	7 22 30·5	122	0·220	121	2·230	27	0·917	26	2·915	+ 189·3393
	240	7 29 42	303 27·5	...	303 27·5	239	7 26 20	28	0·838	27	2·835	121	0·948	120	2·945	− 186·1108
	240	7 29 42	303 27·5	...	303 27·5	241	7 31 15	28	0·852	27	2·859	121	0·974	120	2·976	− 186·0902
	243	7 39 30	303 24·5	...	303 24·5	242	7 36 35	122	0·298	121	2·288	27	0·890	26	2·895	+ 189·4299
XXXVII. Nov. 15, 1874 Juno & λ	244	7 58 35	112 13·5	...	112 13·5	245	8 0 15	114	0·010	113	2·015	34	1·999	33	3·993	+ 158·0263
	247	8 8 19	112 9·5	...	112 9·5	246	8 4 0	35	1·914	34	3·899	113	0·623	112	2·620	− 154·6976
XXXVIII. Nov. 17, 1874 Juno & ι	248	23 10 16	306	59·0	306 59·0	249	23 13 44	101	0·225	100	2·217	48	0·123	47	2·135	+ 106·1090
	251	23 20 52·5	307	11·5	307 11·5	250	23 18 16	49	0·910	48	2·912	100	0·838	99	2·832	− 101·9052
	252	23 23 37	307	10·0	307 10·0	253	23 24 46	49	0·853	48	2·851	100	0·839	99	2·853	− 101·9761
	255	23 35 41·5	306	55·0	306 55·0	254	23 32 11	101	0·314	100	2·310	48	0·030	47	2·040	+ 106·2932
XXXIX. Nov. 18, 1874 Juno & θ	256	22 52 25	233	59·0	233 59·0	257	22 53 56	108	0·649	107	2·639	41	0·830	40	2·835	+ 133·8309
	259	23 11 29	234	4·0	234 4·0	258	22 56 23	42	0·645	41	2·641	107	1·261	106	3·250	− 130·6007
	260	23 14 21·5	234	4·0	234 4·0	261	23 19 54·5	42	0·431	41	2·423	107	1·505	106	3·503	− 131·0619
	263	23 28 17·5	234	2·5	234 2·5	262	23 23 37	108	0·905	107	2·905	41	0·503	40	2·500	+ 134·4229
XL. Nov. 18, 1874 Juno & θ	264	5 32 18	234	34·5	234 34·5	265	5 35 30	109	1·827	108	3·842	39	0·658	38	2·655	+ 141·1984
	267	5 43 58	234	38·5	234 38·5	266	5 41 7	40	0·440	39	2·452	109	0·540	108	2·528	− 138·0730
	268	5 45 15	234	37·5	234 37·5	269	5 46 52	40	0·375	39	2·375	109	0·562	108	2·573	− 138·1769
	271	5 55 56	234	35·5	234 35·5	270	5 51 2	109	1·994	108	3·981	39	0·480	38	2·480	+ 141·5297

Group	Chron. corr.	Bar.	Ther.	Group	Chron. corr.	Bar.	Ther.
	m. s.	in.			m. s.	in.	
XXXIII.	+0 31·5	30·16	68°·8	XXXVII.	+0 32	30·14	68°·1
XXXIV.	+0 31·5	30·16	69·1	XXXVIII.	+0 37	30·09	74·5
XXXV.	+0 32	30·16	69·0	XXXIX.	+0 40	30·09	72·5
XXXVI.	+0 32	30·15	68·5	XL.	+0 40	30·05	71·0

Group — Date — Objects	Position Angles					Distances									
	Rotation number	Time by chronometer	Position circle		Mean	Rotation number	Time by chronometer	Scale A				Scale B				Resulting value, Scale A − Scale B corrected for screw and division error
			Vernier I.	II.				Preceding div.		Following div.		Preceding div.		Following div.		
								Scale	Screw	Scale	Screw	Scale	Screw	Scale	Screw	
		h. m. s.	° ′	′	° ′		h. m. s.									
XLI. Nov. 18, 1874 Juno & μ	272	6 5 31	66	15·5	66 15·5	273	6 7 4	115	0·269	114	2·255	34	0·843	33	2·845	+161·4338
	275	6 21 21	66	17·0	66 17·0	274	6 12 25	35	0·850	34	2·792	114	0·884	113	2·887	−158·0500
	276	6 24 21	66	16·0	66 16·0	277	6 25 31	35	0·946	34	2·935	114	0·761	113	2·760	−157·8028
	279	6 33 59·5	66	17·0	66 17·0	278	6 29 46·5	115	0·072	114	2·085	34	1·049	33	3·045	+161·0447
XLII. Nov. 18, 1874 Juno & μ	280	6 41 4	66 15·5	...	66 15·5	281	6 42 15	114	1·510	113	3·512	34	0·730	33	2·740	+160·7918
	283	6 50 19	66 17·0	...	66 17·0	282	6 46 28	35	0·696	34	2·685	114	0·073	113	2·080	−157·3792
	284	6 52 41·5	66 17·0	...	66 17·0	285	6 53 54	35	0·729	34	2·710	114	0·039	113	2·052	−157·3191
	287	7 2 59	66 15·5	...	66 15·5	286	6 58 9	114	1·360	113	3·368	34	0·865	33	2·865	+160·5155
XLIII. Nov. 18, 1874 Juno & θ	288	7 12 19	234 40·5	...	234 40·5	289	7 13 21·5	110	1·050	109	3·066	39	0·096	38	2·098	+142·9839
	291	7 20 23	234 40·5	...	234 40·5	290	7 16 48·5	39	1·955	38	3·948	109	1·662	108	3·657	−139·6958
	292	7 23 5·5	234 40·5	...	234 40·5	293	7 25 14	39	1·940	38	3·922	109	1·755	108	3·753	−139·8110
	295	7 34 3·5	234 43·0	...	234 43·0	294	7 30 10	110	1·170	109	3·172	39	0·000	38	2·002	+143·1947
XLIV. Nov. 19, 1874 Juno & θ	296	23 33 40	235	30·0	235 30·0	297	23 35 23	114	1·185	113	3·188	35	0·012	34	2·010	+159·1916
	299	23 42 48	235	31·5	235 31·5	298	23 39 19	35	1·883	34	3·876	113	1·886	112	3·887	−155·9953
	300	23 43 53	235	31·0	235 31·0	301	23 46 6·5	35	1·845	34	3·828	113	1·904	112	3·902	−156·0554
	303	23 52 31	235	32·5	235 32·5	302	23 49 15·5	114	1·296	113	3·299	34	1·898	33	3·884	+159·4206
XLV. Nov. 19, 1874 Juno & μ	304	0 1 35	66 43·0	...	66 43·0	305	0 2 59	110	1·352	109	3·350	38	1·906	37	3·909	+143·4642
	307	0 10 7	66 41·5	...	66 41·5	306	0 7 0	39	1·817	38	3·800	109	1·944	108	3·939	−140·1250
	308	0 12 50·5	66 40·0	...	66 40·0	309	0 14 51	39	1·859	38	3·861	109	1·898	108	3·890	−140·0244
	311	0 22 36·5	66 42·5	...	66 42·5	310	0 18 58	110	1·192	109	3·192	39	0·017	38	2·011	+143·2037
XLVI. Nov. 19, 1874 Juno & μ	312	0 29 7	66	43·0	66 43·0	313	0 30 54	110	0·660	109	2·660	38	1·715	37	3·718	+142·9658
	315	0 37 53	66	42·0	66 42·0	314	0 35 0	39	1·588	38	3·594	109	1·227	108	3·226	−139·6295
	316	0 40 20	66	42·5	66 42·5	317	0 41 40	39	1·642	38	3·642	109	1·192	108	3·188	−139·5426
	319	0 47 39·5	66	44·0	66 44·0	318	0 45 8·5	110	0·533	109	2·551	38	1·805	37	3·818	+142·7533
XLVII. Nov. 19, 1874 Juno & θ	320	0 52 52	235 36·5	...	235 36·5	321	0 54 17	114	1·432	113	3·412	34	0·840	33	2·845	+160·5962
	323	1 1 58	235 36·0	...	235 36·0	322	0 59 33·5	35	0·732	34	2·715	114	0·140	113	2·130	−157·3989
	324	1 3 11	235 36·5	...	235 36·5	325	1 4 24	35	0·622	34	2·640	114	0·188	113	2·173	−157·5366
	327	1 11 15	235 37·0	...	235 37·0	326	1 7 49	114	1·558	113	3·561	34	0·734	33	2·729	+160·8452
XLVIII. Nov. 20, 1874 Juno & ι	328	23 4 21·5	281 6·0	...	281 6·0	329	23 7 6	113	0·270	112	2·253	36	0·973	35	2·977	+153·2981
	331	23 15 9	281 1·5	...	281 1·5	330	23 9 40·5	37	1·069	36	3·055	112	0·659	111	2·655	−149·5781
	332	23 17 33	281 3·0	...	281 3·0	333	23 18 39	37	1·025	36	3·020	112	0·739	111	2·740	−149·7007
	335	23 27 12	280 59·0	...	280 59·0	334	23 22 40·5	113	0·359	112	2·340	36	0·824	35	2·818	+153·5417

Group	Chron. corr.	Bar.	Ther.	Group	Chron. corr.	Bar.	Ther.
	m. s.	in.	°		m. s.	in.	°
XLI.	+0 40	30·05	71·0	XLV.	+0 41	30·06	72·8
XLII.	+0 40	30·05	70·8	XLVI.	+0 41	30·06	72·8
XLIII.	+0 40	30·05	70·3	XLVII.	+0 41	30·07	73·5
XLIV.	+0 41	30·06	72·8	XLVIII.	+0 44	30·07	73·8

Group — Date — Objects	Position Angles: Rotation number	Time by chronometer	Position circle: Vernier I.	Position circle: II.	Mean	Distances: Rotation number	Time by chronometer	Scale A: Preceding div. Scale	Scale A: Preceding div. Screw	Scale A: Following div. Scale	Scale A: Following div. Screw	Scale B: Preceding div. Scale	Scale B: Preceding div. Screw	Scale B: Following div. Scale	Scale B: Following div. Screw	Resulting value, Scale A–Scale B corrected for screw and division error
		h. m. s.	° ′	′	° ′		h. m. s.									
XLIX. Nov. 20, 1874 Juno & ν	336	23 33 30	76 25·0	...	76 25·0	337	23 36 0	121	1·235	120	3·235	27	1·850	26	3·850	+187·4180
	339	23 45 42·5	76 25·5	...	76 25·5	338	23 41 51·5	29	0·254	28	2·246	120	1·460	119	3·468	−183·2058
	340	23 50 4	76 25·5	...	76 25·5	341	23 53 42·5	29	0·185	28	2·181	120	1·518	119	3·528	−183·3306
	343	0 3 44	76 27·0	...	76 27·0	342	23 58 23·5	121	1·017	120	3·009	28	0·025	27	2·030	+187·0120
L. Nov. 20, 1874 Juno & ι	344	6 2 25	279 40·0	...	279 40·0	345	6 5 0	114	1·272	113	3·280	34	1·922	33	3·922	+159·3702
	347	6 19 9	279 35·0	...	279 35·0	346	6 9 15	36	0·022	35	2·018	113	1·747	112	3·750	−155·7139
	348	6 22 23	279 34·0	...	279 34·0	349	6 24 37	35	1·950	34	3·934	113	1·838	112	3·837	−155·8793
	351	6 32 53	279 34·0	...	279 34·0	350	6 29 22	114	1·473	113	3·468	34	1·795	33	3·790	+159·6941
LI. Nov. 20, 1874 Juno & ν	352	6 38 16·5	76	49·0	76 49·0	353	6 40 0·5	119	1·621	118	3·610	29	1·477	28	3·478	+180·1673
	355	6 57 47·5	76	48·5	76 48·5	354	6 44 11·5	30	1·722	29	3·722	119	0·002	118	2·003	−176·2797
	356	6 59 40	76	48·0	76 48·0	357	7 0 46	30	1·885	29	3·884	118	1·885	117	3·883	−175·9901
	359	7 12 9	76	50·0	76 50·0	358	7 5 4	119	1·372	118	3·361	29	1·719	28	3·735	+179·6713
LII. Nov. 23, 1874 Juno & ι	360	23 20 23	271 2·5	...	271 2·5	361	23 22 6	127	0·934	126	2·985	21	1·010	20	2·995	+212·0284
	363	23 29 35	271 2·0	...	271 2·0	362	23 26 5·5	22	1·230	21	3·230	126	1·502	125	3·511	−208·2726
	364	23 30 22	271 2·0	...	271 2·0	365	23 31 55	22	1·180	21	3·176	126	1·541	125	3·535	−208·3559
	367	23 38 35	271 0·5	...	271 0·5	366	23 35 33	127	1·098	126	3·103	21	0·908	20	2·902	+212·2408
LIII. Nov. 23, 1874 Juno & χ	368	23 42 30	87	31·5	87 31·5	369	23 44 22	117	0·419	116	2·399	31	1·800	30	3·794	+170·6252
	371	23 50 21	87	33·0	87 33·0	370	23 48 4·5	32	1·970	31	3·951	116	0·784	115	2·785	−166·7993
	372	23 54 20	87	33·0	87 33·0	373	23 56 3	33	0·010	32	2·022	116	0·758	115	2·750	−166·7264
	375	0 6 31	87	33·0	87 33·0	374	0 2 5	117	0·320	116	2·298	31	1·932	30	3·918	+170·3958
LIV. Nov. 23, 1874 Juno & χ	376	0 10 47	87 32·5	...	87 32·5	377	0 12 37	117	0·675	116	2·660	32	0·421	31	2·438	+170·2527
	379	0 19 44	87 35·5	...	87 35·5	378	0 17 14	33	0·638	32	2·633	116	1·039	115	3·037	−166·3953
	380	0 26 0	87 35·5	...	87 35·5	381	0 27 18	33	0·688	32	2·675	116	0·968	115	2·950	−166·2687
	383	0 36 57	87 36·0	...	87 36·0	382	0 34 2	117	0·469	116	2·467	32	0·535	31	2·545	+169·9436
LV. Nov. 23, 1874 Juno & ι	384	0 44 18	270	54·5	270 54·5	385	0 45 35	128	0·042	127	2·018	21	0·792	20	2·800	+213·2768
	387	0 53 1	270	54·5	270 54·5	386	0 50 31	22	0·987	21	2·998	127	0·625	126	2·630	−209·6306
	388	0 55 35	270	54·0	270 54·5	389	0 56 46	22	0·943	21	2·941	127	0·623	126	2·619	−209·6757
	391	1 2 37	270	53·0	270 53·0	390	0 59 45	128	0·126	127	2·120	21	0·682	20	2·689	+213·4812
LVI. Nov. 24, 1874 Juno & ι	384 bis	5 38 35	268	58·0	268 58·0	385 bis	5 43 23	133	1·781	132	3·780	15	1·138	14	3·141	+236·7057
	387 „	5 52 48	268	55·5	268 55·5	386 „	5 48 5	16	1·403	15	3·405	133	0·340	132	2·359	−232·9649
	387 „	5 52 48	268	55·5	268 55·5	388 „	5 54 34	16	1·365	15	3·369	133	0·385	132	2·390	−233·0390
	390 „	6 12 20	268	55·5	268 55·5	389 „	5 58 57·5	133	1·885	132	3·887	15	1·040	14	3·039	+236·9128

Group	Chron. corr.	Bar.	Ther.	Group	Chron. corr.	Bar.	Ther.
	m. s.	in.	°		m. s.	in.	°
XLIX.	+0 44	30·07	73·8	LIII.	+0 54	30·01	73·5
L.	+0 45	30·04	73·0	LIV.	+0 54	30·01	73·5
LI.	+0 45	30·04	73·0	LV.	+0 54	30·01	73·2
LII.	+0 54	30·01	73·7	LVI.	+0 58	29·98	73·5

Group — Date — Objects	Position Angles					Distances									Resulting value, Scale A–Scale B corrected for screw and division error
	Rotation number	Time by chronometer	Position circle: Vernier I.	Position circle: II.	Mean	Rotation number	Time by chronometer	Scale A: Preceding div. Scale	Scale A: Preceding div. Screw	Scale A: Following div. Scale	Scale A: Following div. Screw	Scale B: Preceding div. Scale	Scale B: Preceding div. Screw	Scale B: Following div. Scale	Scale B: Following div. Screw	
		h. m. s.	° ′	′	° ′		h. m. s.									
LVII. Nov. 24, 1874 Juno & χ	391 bis	6 15 15	90 23·0	...	90 23·0	392	6 18 55	111	0·510	110	2·515	38	0·790	37	2·805	+145·7357
	394	6 42 17	24·0	...	90 24·0	393	6 38 47	39	1·048	38	3·043	110	0·778	109	2·801	−141·7328
	394	6 42 17	24·0	...	90 24·0	395	6 44 18	39	1·109	38	3·109	110	0·740	109	2·736	−141·6175
	397	6 55 50	26·25	...	90 26·25	396	6 53 25	111	0·298	110	2·288	38	1·092	37	3·087	+145·2237
LVIII. Nov. 24, 1874 Juno & χ	398	7 0 15	90 27·0	...	90 27·0	399	7 2 8	110	1·600	109	3·608	38	0·558	37	2·570	+145·0585
	401	7 9 23·5	90 27·0	...	90 27·0	400	7 5 13	39	0·685	38	2·685	109	1·960	108	3·982	−141·2748
	401	7 9 23·5	90 27·0	...	90 27·0	402	7 10 36·5	39	0·695	38	2·700	109	1·896	108	3·894	−141·1852
	404	7 16 5	90 28·0	...	90 28·0	403	7 13 43	110	1·493	109	3·505	38	0·620	37	2·628	+144·8945
LIX. Nov. 24, 1874 Juno & ι	405	7 18 53	268	51·0	268 51·0	406	7 20 55	133	1·778	132	3·789	15	0·041	14	2·050	+237·7959
	408	7 28 1	268	49·0	268 49·0	407	7 24 27·5	16	0·321	15	2·330	133	0·358	132	2·357	−234·0482
	...	...	...	...	...	409	7 29 28	16	0·295	15	2·313	133	0·362	132	2·380	−234·0826
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
LX. Nov. 25, 1874 Juno & μ	405 bis	23 24 0	50	0·0	50 0·0	406 bis	23 26 36	78	1·032	77	3·032	70	1·777	69	3·762	+ 15·2843
	408 „	23 37 36·5	49	18·0	49 18·0	407 „	23 34 22	71	1·675	70	3·682	77	1·172	76	3·161	− 11·4604
	409 „	23 38 58·0	49	14·0	49 14·0	410	23 40 42	71	1·727	70	3·730	77	1·150	76	3·125	− 11·3817
	412	23 49 6	49	22·5	49 22·5	411	23 43 58	78	0·930	77	2·931	70	1·880	69	3·862	+ 15·0785
LXI. Nov. 25, 1874 Juno & μ	413	23 53 20	49 16·0	...	49 16·0	414	23 54 51	78	1·365	77	3·363	71	0·434	70	2·432	+ 14·9599
	416	0 1 45	48 42·0	...	48 42·0	415	23 57 29	72	0·342	71	2·325	77	1·510	76	3·508	− 11·1460
	417	0 4 35	48 37·0	...	48 37·0	418	0 6 31	72	0·370	71	2·367	77	1·441	76	3·435	− 11·0403
	420	0 13 1	48 33·0	...	48 33·0	419	0 10 1	78	1·251	77	3·251	71	0·500	70	2·489	+ 14·7872
LXII. Nov. 25, 1874 Juno & μ	421	0 17 12	48 34·5	...	48 34·5	422	0 18 42	78	1·188	77	3·183	71	0·551	70	2·560	+ 14·6590
	424	0 26 13	48 0·0	...	48 0·0	423	0 23 39·5	72	0·462	71	2·463	77	1·333	76	3·320	− 10·8335
	425	0 27 19	47 56·5	...	47 56·5	426	0 28 38	72	0·489	71	2·483	77	1·283	76	3·282	− 10·7669
	428	0 34 35	48 7·0	...	48 7·0	427	0 31 9·5	78	1·080	77	3·098	71	0·608	70	2·615	+ 14·5071
LXIII. Nov. 25, 1874 Juno & μ	429	0 39 20	47	54·0	47 54·0	430	0 42 11	78	0·632	77	2·636	71	0·304	70	2·306	+ 14·3526
	432	0 47 46	47	25·5	47 25·5	431	0 45 16	72	0·194	71	2·190	77	0·791	76	2·791	− 10·5639
	433	0 49 41·5	47	19·0	47 19·0	434	0 50 30	72	0·242	71	2·239	77	0·770	76	2·772	− 10·4961
	436	0 55 50	47	27·5	47 27·5	435	0 53 39	78	0·585	77	2·590	71	0·371	70	2·380	+ 14·2370
LXIV. Nov. 25, 1874 Juno & μ	437	5 47 26·5	33	42·5	33 42·5	438	5 49 10	77	1·102	76	3·110	72	0·367	71	2·374	+ 10·7613
	440	5 55 45	33	42·5	33 42·5	439	5 52 46	73	0·262	72	2·257	76	1·240	75	3·243	− 6·9566
	441	5 57 35	33	42·5	33 42·5	442	5 59 15·5	73	0·308	72	2·312	76	1·215	75	3·212	− 6·8792
	444	6 5 55	33	38·0	33 38·0	443	6 2 33	77	1·063	76	3·070	72	0·440	71	2·443	+ 10·6512

Group	Chron. corr.	Bar.	Ther.	Group	Chron. corr.	Bar.	Ther.
	m. s.	in.	°		m. s.	in.	°
LVII.	+0 58	29·98	73·5	LXI.	+1 1	30·02	74·2
LVIII.	+0 58	29·97	73·5	LXII.	+1 1	30·02	74·2
LIX.	+0 58	29·97	73·0	LXIII.	+1 1	30·03	74·0
LX.	+1 1	30·02	74·2	LXIV.	+1 2	30·00	71·2

Group — Date — Objects	Position Angles					Distances									
	Rotation number	Time by chronometer	Position circle		Mean	Rotation number	Time by chronometer	Scale A				Scale B				Resulting value, Scale A − Scale B corrected for screw and division error
			Vernier I.	II.				Preceding div.		Following div.		Preceding div.		Following div.		
								Scale	Screw	Scale	Screw	Scale	Screw	Scale	Screw	
		h. m. s.	° ′	′	° ′		h. m. s.									
LXV. Nov. 25, 1874 Juno & μ	445	6 8 41	33 24·0	...	33 24·0	446	6 11 5	77	0·852	76	2·865	72	0·335	71	2·330	+ 10·5508
	448	6 17 41·5	32 37·5	...	32 37·5	447	6 14 56	73	0·230	72	2·240	76	1·009	75	2·990	− 6·7381
	449	6 18 56·5	32 28·5	...	32 28·5	450	6 20 33	73	0·258	72	2·263	76	0·991	75	2·985	− 6·7014
	445	6 8 41	33 24·0	...	33 24·0	451	6 24 7	77	0·800	76	2·785	72	0·385	71	2·390	+ 10·4300
LXVI. Nov. 25, 1874 Juno & μ	452	6 33 8	32 0·0	...	32 0·0	453	6 36 26	77	0·705	76	2·707	72	0·419	71	2·418	+ 10·3078
	455	6 42 52	30 53·5	...	30 53·5	454	6 39 15	73	0·371	72	2·368	76	0·902	75	2·901	− 6·5075
	455 bis	6 45 34	30 46·0	...	30 46·0	456	6 46 57	73	0·395	72	2·389	76	0·843	75	2·858	− 6·4338
	458	7 0 1	29 53·5	...	29 53·5	457	6 50 29	77	0·675	76	2·674	72	0·525	71	2·548	+ 10·1593
LXVII. Nov. 25, 1874 Juno & μ	459	7 9 34·5	30	20·0	30 20·0	460	7 10 45	73	0·635	72	2·635	76	0·844	75	2·825	− 6·1746
	462	7 17 25	29	7·0	29 7·0	461	7 13 50	77	0·675	76	2·670	72	0·745	71	2·755	+ 9·9468
	463	7 21 21	28	46·5	28 46·5	...	...	...	...	...	...	...	...	...	...	...
	459	7 9 34·5	30	20·0	30 20·0	...	...	...	...	...	...	...	...	...	...	...
LXVIII. Nov. 26, 1874 Juno & μ	464	23 28 41	297	43·5	297 43·5	465	23 30 6·5	77	1·054	76	3·063	72	0·717	71	2·730	+ 10·3625
	467	23 35 33	297	12·0	297 12·0	466	23 33 1	73	0·569	72	2·577	76	1·240	75	3·239	− 6·6438
	468	23 37 23	297	7·0	297 7·0	469	23 38 30	73	0·540	72	2·550	76	1·280	75	3·264	− 6·7039
	471	23 43 30	296	49·5	296 49·5	470	23 40 40	77	1·113	76	3·121	72	0·662	71	2·654	+ 10·4868
LXIX. Nov. 26, 1874 Juno & μ	472	23 46 7	296 32·0	...	296 32·0	473	23 47 21	77	0·220	76	2·818	72	0·278	71	2·279	+ 10·5622
	475	23 52 31	296 24·0	...	296 24·0	474	23 50 6	73	0·150	72	2·150	76	1·015	75	3·010	− 6·8344
	476	23 54 5·5	296 17·0	...	296 17·0	477	23 55 18	73	0·111	72	2·130	76	1·039	75	3·042	− 6·8924
	479	0 1 20	295 41·5	...	295 41·5	478	23 57 54	77	0·601	76	2·600	72	0·234	71	2·241	+ 10·6795
LXX. Nov. 26, 1874 Juno & μ	480	0 3 50	295 31·0	...	295 31·0	481	0 5 25	77	0·930	76	2·940	72	0·199	71	2·210	+ 10·7498
	483	0 11 2	295 22·0	...	295 22·0	482	0 7 31	73	0·084	72	2·078	76	1·078	75	3·083	− 6·9746
	484	0 14 50	295 10·5	...	295 10·5	485	0 16 2	73	0·037	72	2·040	76	1·165	75	3·164	− 7·1015
	487	0 41 31	293 31·5	...	293 31·5	486	0 18 12	77	1·000	76	2·990	72	0·123	71	2·139	+ 10·8869
LXXI. Nov. 26, 1874 Juno & μ	488	5 51 35	282 35·0	...	282 35·0	489	5 53 32	78	1·300	77	3·304	71	0·572	70	2·580	+ 14·7526
	491	6 0 9	282 35·5	...	282 35·5	490	5 57 0	72	0·424	71	2·431	77	1·512	76	3·511	− 11·0504
	492	6 2 46	282 23·5	...	282 23·5	493	6 4 56	72	0·382	71	2·390	77	1·550	76	3·555	− 11·1323
	495	6 13 10	282 10·0	...	282 10·0	494	6 9 59	78	1·430	77	3·428	71	0·479	70	2·478	+ 14·9747
LXXII. Nov. 26, 1874 Juno & μ	496	6 40 37	281	29·5	281 29·5	497	6 42 37	78	1·034	77	3·045	70	1·710	69	3·695	+ 15·3585
	499	6 48 33	281	27·5	281 27·5	498	6 45 6·5	71	1·560	70	3·573	77	1·240	76	3·224	− 11·6403
	499	6 48 33	281	27·5	281 27·5	500	6 53 38	71	1·492	70	3·503	77	1·289	76	3·261	− 11·7511
	502	6 59 7	281	10·5	281 10·5	501	6 56 20	78	1·088	77	3·103	70	1·622	69	3·609	+ 15·5020

Group	Chron. corr.	Bar.	Ther.	Group	Chron. corr.	Bar.	Ther.
	m. s.	in.	°		m. s.	in.	°
LXV.	+ 1 2	30·00	71·2	LXIX.	+ 1 4	30·03	74·4
LXVI.	+ 1 2	30·00	71·2	LXX.	+ 1 4	30·08	74·3
LXVII.	+ 1 2	30·00	71·2	LXXI.	+ 1 5	30·07	73·3
LXVIII.	+ 1 4	30·03	74·4	LXXII.	+ 1 5	30·07	73·3

Group — Date — Objects	Position Angles: Rotation number	Time by chronometer	Position circle: Vernier I.	Position circle: II.	Mean	Distances: Rotation number	Time by chronometer	Scale A: Preceding div. Scale	Scale A: Preceding div. Screw	Scale A: Following div. Scale	Scale A: Following div. Screw	Scale B: Preceding div. Scale	Scale B: Preceding div. Screw	Scale B: Following div. Scale	Scale B: Following div. Screw	Resulting value Scale A – Scale B corrected for screw and division error
		h. m. s.	° ′	′	° ′		h. m. s.									
LXXIII. Nov. 26, 1874 Juno & μ	503	7 1 47	281	7·0	281 7·0	504	7 2 59	78	1·140	77	3·136	70	1·590	69	3·559	+15·5890
	506	7 8 52	281	1·5	281 1·5	505	7 6 33·5	71	1·432	70	3·433	77	1·337	76	3·326	−11·8666
	506 bis	7 9 45	280	58·5	280 58·5	507	7 11 44	71	1·390	70	3·392	77	1·356	76	3·361	−11·9345
	509	7 18 2	280	35·5	280 35·5	508	7 14 7	78	1·180	77	3·178	70	1·480	69	3·478	+15·7252
LXXIV. Nov. 26, 1874 Juno & μ	510	7 19 50	280 49·0	...	280 49·0	Distance was not observed in this group										
	511	7 22 45	280 31·0	...	280 31·0											
	512	7 26 35	280 40·0	...	280 40·0											
	513	7 29 24	280 26·5	...	280 26·5											
LXXV. Nov. 27, 1874 Juno & μ	510 bis	23 27 49	270	21·5	270 21·5	511 bis	23 44 29	83	0·423	82	2·425	66	1·380	65	3·371	+33·0736
	513 „	23 49 44	271	4·0	271 4·0	512 „	23 47 0	67	1·270	66	3·275	82	0·625	81	2·632	−29·3338
	514	23 51 54	270	58·5	270 58·5	515	23 53 0	67	1·265	66	3·280	82	0·620	81	2·619	−29·3249
	517	23 59 35	271	18·0	271 18·0	516	23 56 30	83	0·430	82	2·439	66	1·328	65	3·342	+33·1241
LXXVI. Nov. 28, 1874 Juno & μ	518	6 31 1	265	47·0	265 47·0	519	6 32 12	86	1·238	85	3·240	62	1·385	61	3·397	+47·8747
	521	6 38 21	265	26·5	265 26·5	520	6 35 27	63	1·313	62	3·318	85	1·474	84	3·466	−44·1272
	522	6 40 10	265	26·5	265 26·5	523	6 43 13	63	1·286	62	3·286	85	1·504	84	3·495	−44·1859
	525	6 57 52	265	47·0	265 47·0	524	6 53 40	86	1·330	85	3·329	62	1·242	61	3·238	+48·1132
LXXVII. Nov. 29, 1874 Juno & ν	526	5 57 38	126	15·5	126 15·5	527	5 59 56	78	1·383	77	3·376	71	0·448	70	2·450	+14·9568
	529	6 5 20	126	12·0	126 12·0	528	6 3 20	72	0·305	71	2·310	77	1·560	76	3·558	−11·2184
	530	6 6 44	126	12·0	126 12·0	531	6 8 33	72	0·335	71	2·323	77	1·548	76	3·551	−11·1877
	533	6 20 35	126	57·0	126 57·0	532	6 12 9	78	1·321	77	3·330	71	0·500	70	2·501	+14·8523
LXXVIII. Nov. 29, 1874 Juno & ν	534	6 23 37·5	128 18·0	...	128 18·0	535	6 25 42	78	0·712	77	2·720	70	1·984	69	3·981	+14·7554
	537	6 32 54	127 3·5	...	127 3·5	536	6 29 23	71	1·855	70	3·865	77	0·881	76	2·879	−10·9883
	538	6 34 47	127 5·0	...	127 5·0	539	6 36 46	71	1·878	70	3·874	77	0·835	76	2·830	−10·9244
	541	6 43 34·5	127 51·0	...	127 51·0	540	6 39 41·5	78	0·649	77	2·650	71	0·014	70	2·015	+14·6593
LXXIX. Nov. 29, 1874 Juno & ν	542	6 46 35	127 57·0	...	127 57·0	544	6 48 40	78	0·596	77	2·610	71	0·060	70	2·060	+14·5684
	546	6 55 57	127 48·0	...	127 48·0	545	6 51 48	71	1·915	70	3·933	77	0·777	76	2·772	−10·8185
	547	6 59 20	127 55·0	...	127 55·0	548	7 1 20	71	1·952	70	3·953	77	0·719	76	2·711	−10·7302
	550	7 11 5	127 52·0	...	127 52·0	549	7 6 51	78	0·510	77	2·502	71	0·155	70	2·165	+14·3719
LXXX. Nov. 30, 1874 Juno & ν	551	0 19 28	179	57·5	179 57·5	552	0 24 59	73	0·452	72	2·472	76	1·110	75	3·095	− 6·6186
	554	0 34 15	181	38·5	181 38·5	553	0 27 45	77	0·935	76	2·940	72	0·586	71	2·585	+10·3789
	555	0 36 36	181	41·5	181 41·5	556	0 37 45	77	0·935	76	2·940	72	0·604	71	2·603	+10·3608
	558	0 43 32·5	181	48·5	181 48·5	557	0 40 37	73	0·453	72	2·443	76	1·120	75	3·103	− 6·6416

Group	Chron. corr.	Bar.	Ther.	Group	Chron. corr.	Bar.	Ther.
	m. s.	in.	°		m. s.	in.	°
LXXIII.	+1 5	30·07	73·3	LXXVII.	+1 37	30·00	69·5
LXXIV.	+1 5	30·05	72·8	LXXVIII.	+1 37	30·00	69·5
LXXV.	+1 8	30·08	72·5	LXXIX.	+1 37	30·00	67·8
LXXVI.	+1 34	30·02	70·5	LXXX.	+1 39	30·03	69·3

Group — Date — Objects	Position Angles					Distances									
	Rotation number	Time by chronometer	Position circle		Mean	Rotation number	Time by chronometer	Scale A				Scale B				Resulting value, Scale A–Scale B corrected for screw and division error
			Vernier I.	II.				Preceding div.		Following div.		Preceding div.		Following div.		
								Scale	Screw	Scale	Screw	Scale	Screw	Scale	Screw	
		h. m. s.	° ′	′	° ′		h. m. s.									
LXXXI. Nov. 30, 1874 Juno & ν	559	0 45 11	181 36·5	...	181 36·5	560	0 46 16	73	0·239	72	2·243	76	0·917	75	2·940	− 6·6594
	562	0 52 4	182 50·0	...	182 50·0	561	0 48 40	77	0·765	76	2·760	72	0·390	71	2·401	+ 10·3868
	563	0 53 30	182 56·5	...	182 56·5	564	0 54 44	77	0·750	76	2·763	72	0·430	71	2·430	+ 10·3469
	566	1 0 28	182 58·5	...	182 58·5	565	0 58 7	73	0·241	72	2·249	76	0·909	75	2·920	− 6·6411

Group	Chron. corr.	Bar.	Ther.
LXXXI.	+ 1 m. 39 s.	30·03 in.	69·3°

CHAPTER VII.

VALUE OF THE SCALE AND DETERMINATION OF THE ZERO OF THE POSITION CIRCLE.

To determine the angular value of the scale, or rather of a normal screw revolution, two zones of stars were observed at Mauritius—one in Perseus, the other in Hydra. The details of the observations will be found p. 86 to p. 94.

These zones have also been observed by the other heliometer observers, and the places of the component stars have been determined by meridian observations at Berlin, Leipzig, and elsewhere; a few meridian observations of the Perseus zone were made at Dun Echt, and communicated to Dr. Auwers.

The whole of these observations have been discussed by him, and compared with the old observations for proper motion.

Dr. Auwers has communicated the results, with the following remarks:—

'The table contains only preliminary positions, as I think I shall still receive other series of observations; but I think I have the best and most extensive ones. I do not think that the addition of the outstanding observations will change in any instance (except for the indifferent star *a* of the Perseus zone) the places so much as $0^s.02$ or $0''.30$.

'After the AR and Declination I have given the weight ω of these co-ordinates, assuming $\omega = 1$ for a probable error of $\pm 0^s.04$ in AR or $\pm 0''.50$ in declination. But these weights will not give quite a correct judgment of the accuracy of the preliminary places, the actual probable errors of these being a little larger than those computed by the given weights. But, at all events, the places appear to be very reliable.'

PERSEUS ZONE.—MEAN PLACES FOR EQUINOX AND EPOCH 1875·0, *except for Star d (whose proper motion cannot be determined, for want of observations before* 1874*), whose place is given for the mean epoch of the observations* 1875·9 *and* 1875·3 *respectively.*

Star	Right ascension, 1875·0	ω	Ann. Prec.	Sec. Var.	P.M.	Declination, 1875·0	ω	Ann. Prec.	Sec. Var.	P.M.
	h. m. sec.		sec.	sec.	sec.	° ′ ″		″	″	″
a	3 9 1·600	13·0	+3·8967	+0·0342	−0·0008	+40 1 14·95	8·1	+13·611	−0·419	−0·038
b	6 1·125	80·1	·8760	·0340	−0·0005	39 38 57·84	36·3	13·804	·409	−0·020
c	3 3 13·520	46·3	·8523	·0336	−0·0031	39 8 5·77	13·5	13·980	·400	+0·013
d	2 59 31·632	56·7	·8254	·0333	...	38 36 10·77	22·0	14·210	·395	...
e	57 10·261	57·7	·8110	·0333	+0·0098	38 21 15·04	25·9	14·355	·386	−0·096
f	53 55·673	56·8	·8009	·0333	−0·0027	38 22 53·41	20·5	14·551	·383	+0·006
g	50 7·169	56·9	·7811	·0332	−0·0013	38 6 38·44	17·9	14·779	·373	−0·013
h	45 49·569	51·6	·7595	·0331	+0·0036	37 49 35·63	26·8	15·031	·360	−0·073
i	42 41·850	50·3	·7482	·0333	+0·0156	37 48 8·17	23·4	15·210	·355	−0·089
k	2 39 39·510	79·8	+3·7250	+0·0328	−0·0034	+37 15 56·02	35·3	+15·382	−0·349	−0·027

The star *a* is double; the place is that of the preceding (the brighter) component. This star is not to be taken into account in the determinations of screw value.

HYDRA ZONE.—MEAN PLACES FOR EQUINOX AND EPOCH 1875·0.

Star	Right ascension, 1875·0	ω	Ann. Prec.	Sec. Var.	P.M.	Declination, 1875·0	ω	Ann. Prec.	Sec. Var.	P.M.
	h. m. sec.		sec.	sec.	sec.	° ′ ″		sec.	sec.	sec.
a	8 23 8·262	73·7	+3·0620	−0·0041	−0·0048	−0 32 42·03	28·2	−11·726	−0·359	−0·018
b	22 44·188	19·5	·0744	·0043	+0·0011	+0 6 49·59	11·3	11·698	·361	+0·015
c	21 49·492	33·1	·0847	·0044	−0·0041	0 39 22·41	9·6	11·633	·364	−0·034
d	21 4·137	44·2	·0958	·0046	+0·0084	1 14 12·55	9·6	11·587	·365	+0·004
e	19 20·158	13·5	·1103	·0048	−0·0027	1 58 53·39	7·9	11·455	·369	−0·066
f	8 19 6·149	83·6	+3·1204	−0·0049	−0·0017	+2 30 27·17	33·7	−11·438	−0·371	−0·053

From these data the following tables have been computed.

Table I. gives, for each pair of stars measured, the distance s and position angle at the middle point between the stars p, from Dr. Auwers's stars' places reduced to 1874·0 and calculated by the rigid formulæ.

The table also gives the effect on the distance and position angle of a change of + 1″ in the $A\!R$ and declination of the first star of each pair. The sign of these factors must be reversed for the second star of the pair.

Table II. gives the annual effect of Auwers's proper motions in changing these distances and position angles.

Table III. gives the annual increase of the mean position-angle due to precession, and is to be employed along with Table II. to convert the mean distances and position angles given for 1874·0 to 1874·0 + t, where t is any *whole* number of years.

The annual increase of position angle = 20″·054 × sin α_0 sec δ_0.

Table IV. gives the logs. of the constants by which an observed distance or position angle is corrected for the effects of precession, nutation, and aberration.

$$\text{For distance} \quad \begin{cases} \alpha = -2 \sin \tfrac{1}{2}s \, (\cos \delta_0 \sin \alpha_0 \tan \omega \sin \delta_0) \\ \beta = \quad 2 \sin \tfrac{1}{2}s \, (\cos \delta_0 \cos \alpha_0) \end{cases}$$

$$\text{For position angle} \quad \begin{cases} \alpha_1 = \tan \delta \cos \alpha \\ \beta_1 = \tan \delta \sin \alpha \\ \gamma_1 = 20''{\cdot}054 \sec \delta \sin \alpha \\ \delta_1 = \sec \delta \cos \alpha \end{cases}$$

where ω is the obliquity of the ecliptic.

Then the mean distance on January 1 = observed distance $- (\alpha \, \text{A} + \beta \, \text{B} + t\mu)$;

" " pos. angle " = observed pos. angle $- (\alpha_1 \, \text{A} + \beta_1 \, \text{B} + \gamma_1 \, \text{C} + \delta_1 \, \text{D} + t\mu_1)$;

where A, B, C, D are the usual day numbers of the 'Nautical Almanac,' whose logs. are given on p. xx. of each month; and μ and μ_1, the annual proper motions from Table II.

Table V. facilitates the computation of probable errors and weights of the zone observations.

The *first* column, headed ϵ_α, gives the probable error of the tabular difference of $\mathcal{A}$R of the two stars = $\sqrt{\text{sum of squares of probable error of } \mathcal{A}\text{R of each star.}}$

The *second* column, ϵ_δ, gives the probable error of tabular difference of declination.

The probable error in $\mathcal{A}$R for each star has been assumed

$$= \pm \frac{0^s{\cdot}04}{\sqrt{w}} = \pm \frac{0''{\cdot}60}{\sqrt{w}}.$$

The probable error in declination for each star has been assumed

$$= \pm \frac{0''{\cdot}50}{\sqrt{w}}.$$

The *third* column gives the probable error of one heliometric observation computed by the formula found applicable to the measures made at Dun Echt—

$$e = \pm \left(0''{\cdot}05 + 0''{\cdot}03 \times \frac{s''}{1000}\right).$$

The *fourth* column gives the square of the probable error in distance due to probable error $\Delta\alpha$, viz.

$$(f \times \epsilon_{1\alpha})^2 = (\epsilon_\alpha \times \text{factor for change of } 1'' \text{ in } \mathcal{A}\text{R})^2.$$

The *fifth* column gives the square of the corresponding error due to probable error in $\Delta\delta$.

The *sixth* column gives the value of e^2.

The *seventh* and *eighth* columns give the squares of the probable errors affecting the position angle, due to probable errors in $\mathcal{A}$R and declination.

The *ninth* column gives the effect of an error of + 1′ in the observed position angle on the distance projected on the great circle joining the extreme stars of the zone = ϵ_q.

Table VI. gives ϵ_p the probable error of the position angle as determined by the meridian observations

$$= \pm \sqrt{(f''' \epsilon_{1\alpha})^2 + (f'''' \epsilon_{1\delta})^2}.$$

$\epsilon_p \times \epsilon_q$ is the probable error of the projection on the great circle joining the extreme stars, and the square of this probable error is given in the column marked $(\epsilon_p \times \epsilon_q)^2$.

TABLE I.—MEAN DISTANCES AND POSITION ANGLES OF PAIRS OF STARS IN THE PERSEUS AND HYDRA ZONES, COMPUTED FOR 1874·0 FROM AUWERS'S PLACES FOR 1875·0.

Name of stars		Distance, 1874·0	Factor for change of +1″ in		Position angle, 1874·0	Factor for change of +1″ in	
			$\Delta\alpha$	$\Delta\delta$		$\Delta\alpha$	$\Delta\delta$
			f'	f''		f'''	f''''
Perseus zone	*a–b*	247″·67	+0·646	+0·541	57° 14′·63	+0·578	−1·170
„ „	*a–c*	5134·61	·604	·621	51 35·66	·321	0·525
„ „	*b–c*	2684·22	·559	·690	46 21·86	·683	0·927
„ „	*c–d*	3222·18	·626	·594	53 31·82	·494	0·858
„ „	*d–e*	1886·36	·689	+0·475	61 38·92	+0·678	1·604
„ „	*e–f*	2290·43	·783	−0·043	92 27·26	−0·050	1·500
„ „	*f–g*	2862·98	·738	+0·341	70 5·08	+0·321	1·129
„ „	*g–h*	3213·33	·747	·318	71 26·13	·267	1·010
„ „	*h–i*	2226·33	·789	·039	87 44·67	·048	1·550
„ „	*i–k*	2904·58	·592	·665	48 17·70	·624	0·884
„ „	*c–e*	5095·16	·651	·552	56 30·86	·290	0·563
„ „	*e–g*	5061·41	·774	·173	80 1·20	·073	0·669
„ „	*h–k*	4842·23	·721	·417	65 20·58	·235	0·645
„ „	*b–k*	20456·96	+0·711	+0·419	65 13·59	+0·055	−0·152
Hydra zone	*a–b*	2398·93	+0·151	−0·989	171 20·15	−1·417	−0·216
„ „	*b–c*	2118·17	·387	·922	157 12·56	1·496	·629
„ „	*c–d*	2198·08	·310	·951	161 57·79	1·487	·484
„ „	*d–e*	3101·19	·503	·864	149 49·06	0·958	·558
„ „	*e–f*	1905·38	·110	·994	173 40·09	1·793	·199
„ „	*a–c*	4482·96	·264	·965	164 42·80	0·740	·202
„ „	*c–e*	5270·43	·425	·905	154 51·00	0·590	·277
„ „	*a–d*	6679·292	·279	·960	163 48·46	0·494	·144
„ „	*d–f*	4904·69	·361	·933	158 51·40	0·654	·253
„ „	*c–f*	7100·53	·345	·939	159 48·99	0·454	·167
„ „	*a–f*	11573·49	+0·314	−0·950	161 42·46	−0·282	−0·093

TABLE II.—ANNUAL EFFECT OF PROPER MOTION.

PERSEUS ZONE			HYDRA ZONE		
Stars	On distance μ	On position angle μ'	Stars	On distance μ	On position angle μ'
b–c	±0″·000	+0′·004	*a–b*	+0″·020	+0′·118
c–d	...	...	*b–c*	−0·015	−0·148
d–e	...	...	*c–d*	−0·022	+0·298
e–f	+0·103	+0·059	*d–e*	+0·024	−0·198
f–g	+0·004	−0·023	*e–f*	+0·011	+0·030
g–h	−0·036	−0·081	*a–c*	−0·018	+0·005
h–i	−0·141	−0·034	*c–e*	−0·038	+0·003
i–k	+0·128	+0·123	*a–d*	−0·034	+0·101
c–e	−0·066	−0·117	*d–f*	+0·002	−0·113
e–g	+0·115	+0·068	*c–f*	−0·030	+0·013
h–k	+0·057	+0·055			

TABLE III.—ANNUAL EFFECT OF PRECESSION ON POSITION ANGLES.

PERSEUS ZONE		HYDRA ZONE	
b–c	+0′.312	*a–b*	+0′.271
c–d	·305	*b–c*	·272
d–e	·300	*c–d*	·273
e–f	·295	*d–e*	·274
f–g	·290	*e–f*	·275
g–h	·284	*a–c*	·275
h–i	·278	*a–d*	·272
i–k	·273	*c–e*	·273
c–e	·303	*c–f*	·274
e–g	·292	*d–f*	+0·274
h–k	+0·275		

TABLE IV.—CONSTANTS FOR CORRECTING DISTANCES AND POSITION ANGLES OF STARS OBSERVED AT MAURITIUS, FOR EFFECT OF PRECESSION, ABERRATION, AND NUTATION.

Name of stars		Distances		Position angles			
		α	β	α_1	β_1	γ_1	δ_1
Perseus zone	*b–c*	−8·0345	+7·8430	+9·7550	+9·7721	+1·2719	+9·9526
,, ,,	*c–d*	8·1107	7·9321	9·7532	9·7580	1·2627	9·9557
,, ,,	*d–e*	7·8675	7·7004	9·7528	9·7462	1·2545	9·9590
,, ,,	*e–f*	7·9556	7·7979	9·7566	9·7393	1·2486	9·9636
,, ,,	*f–g*	8·0476	7·9016	9·7609	9·7303	1·2408	9·9692
,, ,,	*g–h*	8·0921	7·9601	9·7634	9·7174	1·2307	9·9745
,, ,,	*h–i*	7·9280	7·8083	9·7673	9·7071	1·2218	9·9798
,, ,,	*i–k*	8·0390	7·9302	9·7679	9·6960	1·2134	9·9832
,, ,,	*c–e*	8·3085	8·1342	9·7536	9·7540	1·2598	9·9572
,, ,,	*e–g*	8·2974	8·1463	9·7576	9·7332	1·2439	9·9662
,, ,,	*h–k*	−8·2636	+8·1499	+9·7657	+9·6997	+1·2170	+9·9808
Hydra zone	*a–b*	−7·9750	−7·8329	+7·3441	−7·4871	+1·2116	−9·7664
,, ,,	*b–c*	7·9234	7·7762	−7·5920	+7·7376	1·2125	9·7647
,, ,,	*c–d*	7·9426	7·7898	7·9806	8·1295	1·2137	9·7626
,, ,,	*d–e*	8·0967	7·9360	8·2079	8·3619	1·2155	9·7593
,, ,,	*e–f*	7·8888	7·7217	8·3498	8·5077	1·2169	9·7568
,, ,,	*a–c*	8·2473	8·1023	6·7573	6·9019	1·2122	9·7651
,, ,,	*a–d*	8·4223	8·2745	7·5459	7·6923	1·2128	9·7642
,, ,,	*c–e*	8·3253	8·1675	8·1227	8·2751	1·2149	9·7603
,, ,,	*c–f*	8·4559	8·2966	8·2014	8·3543	1·2151	9·7600
,, ,,	*d–f*	−8·2969	−8·1348	−8·2735	+8·4279	+1·2157	−9·7591
τ^6 and τ^7 Eridani . . .		−7·8271	+7·7844	−9·4033	−9·5621	+1·2560	+9·7950
ξ^1 and ξ^2 Can. Maj. . .		−7·0485	−7·2352	+8·7235	−9·6266	+1·3351	−9·1299
Position angle stars, γ and δ		−7·8769	−7·7077	+9·2979	−9·5677	+1·2823	−9·7104

TABLE V.—TABLE TO FACILITATE COMPUTATION OF PROBABLE ERRORS AND WEIGHTS.

Name of stars		Probable error of difference of Æ and declination		P. E. of one heliometer observation	Squares of probable errors affecting the distance			Squares of probable errors affecting the position angle		Effect of change of +1′ in the position angle on the projected distance between extreme stars
		Æ ϵ_α	Declination ϵ_δ	ϵ	Due to Æ $(f^1 \times \epsilon_\alpha)^2$	Due to declination $(f'' \times \epsilon_\delta)^2$	Due to observations with heliometer, ϵ^2	Due to Æ $(f''' \times \epsilon_{1\alpha})^2$	Due to declination $(f'''' \times \epsilon_{1\delta})^2$	ϵ_q
Perseus zone	*b–c*	±0″·111	±0″·159	±0″·128	·003844	·011881	·015625	·005776	·021609	+0″·252
,, ,,	*c–d*	·118	·172	·146	·005476	·010404	·041006	·003364	·021904	+0·189
,, ,,	*d–e*	·112	·145	·107	·005929	·004761	·037196	·005776	·053824	+0·034
,, ,,	*e–f*	·112	·148	·119	·007744	·000036	·022139	·000025	·049284	−0·305
,, ,,	*f–g*	·113	·162	·137	·006889	·003025	·021941	·001296	·033489	−0·071
,, ,,	*g–h*	·116	·152	·146	·007569	·002304	·028683	·000961	·023409	−0·101
,, ,,	*h–i*	·119	·142	·116	·008836	·000036	·031189	·000036	·048400	−0·249
,, ,,	*i–k*	·108	·133	·137	·004096	·007744	·022328	·004489	·013689	+0·245
,, ,,	*c–e*	·118	·168	·203	·005929	·008649	·030609	·001156	·008836	+0·226
,, ,,	*e–g*	·112	·153	·200	·007569	·000676	·055787	·000064	·010404	−0·378
,, ,,	*h–k*	·107	·128	·194	·005929	·002809	·048245	·000625	·006889	−0·004
,, ,,	*b–k*	·095	·118	...	·004624	·002401	...	...	...	±0·000
Hydra zone	*a–b*	±0·153	±0·176	±0·122	·000529	·030276	·014884	·047089	·001444	−0·116
,, ,,	*b–c*	·172	·219	·113	·004356	·040804	·012769	·065536	·019044	+0·049
,, ,,	*c–d*	·138	·228	·116	·001849	·047089	·013456	·042025	·012100	−0·003
,, ,,	*d–e*	·187	·240	·143	·008836	·042436	·020449	·032041	·017690	+0·186
,, ,,	*e–f*	·176	·197	·107	·000361	·038416	·011449	·099225	·001521	−0·115
,, ,,	*a–c*	·125	·186	·185	·001089	·032041	·034225	·011025	·001369	−0·069
,, ,,	*c–e*	·194	·240	·210	·006724	·046656	·044100	·013225	·004356	+0·155
,, ,,	*a–d*	·114	·186	·251	·001024	·031684	·063001	·003136	·000729	−0·070
, ,,	*d–f*	·111	·184	·217	·001681	·029584	·047089	·005476	·002209	+0·070
,, ,,	*c–f*	·123	·184	·263	·001764	·029929	·069169	·002704	·000961	+0·069
,, ,,	*a–f*	·096	·128	...	·000900	·014941	...	·000729	·000121	...

TABLE VI.

Perseus Zone			Hydra Zone		
	ϵ_p	$(\epsilon_p \times \epsilon_q)^2$		ϵ_p	$(\epsilon_p \times \epsilon_q)^2$
b–c	±0′·166	·001764	*a–b*	±0′·218	·000676
c–d	·156	·000841	*b–c*	·293	·000144
d–e	·244	·000064	*c–d*	·233	·000036
e–f	·222	·004624	*d–e*	·223	·001681
f–g	·186	·000169	*e–f*	·317	·001225
g–h	·156	·000256	*a–c*	·100	·000049
h–i	·220	·002916	*c–e*	·132	·000576
i–k	·164	·001600	*a–d*	·062	·000036
c–e	·100	·000529	*d–f*	·087	·000036
e–g	·102	·001444	*c–f*	·062	·000016
h–k	·087	·000000			

There are not sufficient data at present for computing the probable errors of absolute position-angle determinations by means of the heliometer; but, considering the errors produced by flexure, the errors of the equatorial adjustments, and the uncertainties of these determinations, it is extremely improbable that the observed position angles will have so small a probable error as the quantities in columns ϵ_p (Table VI.)

It has, therefore, been decided to employ the zigzag distances of the zone—that is, to adopt the position angles as determined by meridian observations, and regard their probable errors as increasing by a definite amount the probable error of the whole distance.

The probable error thus introduced is the square root of the sum of the values of $(\epsilon_p \times \epsilon_q)^2$ (Table VI.), corresponding to the pairs of stars measured. Thus, taking the Perseus zone as measured at Mauritius, viz.

$$b-c,\ c-e,\ e-g,\ g-h,\ h-k,$$

the computation of the whole probable error of the zigzag distance will be—

Squares of errors affecting the determination by meridian observations of the extreme distance b–p . .	$(f' \times \epsilon_a)^2$	0·004624	
	$(f'' \times \epsilon_a)^2$	·002401	
		———	·007025$\surd$ = ±0″·084
Squares of errors due to position angles as determined by meridian observations $(\epsilon_p \times \epsilon_q)^2$ . . .	b–c	0·001764	
	c–e	·000529	
	e–g	·001444	
	g–h	·000256	
	h–k	·000000	
		———	·003993$\surd$ = ±0″·063
Squares of errors due to heliometer observation e^2 .	b–c	0·015625	
	c–e	·030609	
	e–g	·055787	
	g–h	·028683	
	h–k	·048245	
		———	·178949$\surd$ = ±0″·423
			·189967$\surd$ = ±0″·436

Thus the probable error of the distance b–k is ± 0″·084, and the probable error due to the probable errors of position angles ± 0″·063; the resulting probable error of the zigzag distance is ± 0″·105, as determined by the meridian observations. The introduction of the probable errors due to the heliometer observations amounting ± 0″·423 raises the probable error of our measurement of the zone to ± 0″·436.[1]

It is true that Dr. Auwers has said 'the actual probable errors are a little larger than those computed by the given weights,' but, on the other hand, the climate of Mauritius is better than Dun Echt, both as to quality of definition and uniformity of temperature, rendering it probable that the estimate of the probable error of one heliometer measure is too great, and that the probable error ± 0″·436 very nearly represents the probable error of the measurement of the zone.

It is to be regretted that more time was not available for measuring the zone more

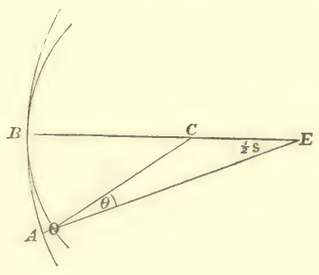
[1] This computation supposes each distance to have been measured only once. When a distance is observed n times the corresponding value of e^2 becomes $\frac{e^2}{n}$.

frequently, so as to join the measures more nearly of the same weight with that of the absolute determination.

The probable error of the determination gives ± 0″·021 for a distance of 1000″, an accuracy sufficient for the Juno series, where the change of distance between the evening and morning observations seldom amounts to 500″, and the probable error of such value will not amount to ± 0″·01.

The scale value is confirmed by three independent measures of the Hydra zone. To deduce from these measures the value of the scale the first step is to determine whether the value of angles measured is strictly proportional to the scale readings.

Fig. 17.



If, for example, the radius of curvature of the cylindrical slide is shorter than the focal length of the object glass, it is obvious that the optical centres of the segments will approach nearer and nearer to the focus of the eye-piece, the larger the angle measured, just as the reverse would take place were the slide plane *a* of a radius of curvature greater than the focal length of the object glass.

Thus let BE be the focal length $= f$;

BC the radius of curvature of the cylindrical slide $= r$;

BEA the half of the distance measured $= \frac{1}{2}s$.

Then BA being an arc whose centre is E, A is the point where the optical centre of the segment should be; but BO being an arc whose centre is C, the form of the slide will cause the optical centre to be at O, and AO is the amount of approach of the optical centre to the eye-piece $= \Delta f$. Join CO and put the angle $COE = \theta$.

Then
$$\sin\theta = \frac{\sin\frac{1}{2}s \times CE}{CO} = \frac{\sin\frac{1}{2}s\,(f-r)}{r};$$

and
$$CO = EC\cos\tfrac{1}{2}s + CO\cos\theta = (f-r)\cos\tfrac{1}{2}s + r\cos\theta;$$

$$\text{and } \Delta f = f - (f-r)\cos\tfrac{1}{2}s - r\cos\theta.$$

In all actual cases of $(f-r)$ and s that are likely to occur in practice the value of $\cos\theta$ cannot differ sensibly from unity; hence

$$\Delta f = (f-r) \times (1 - \cos\tfrac{1}{2}s),$$

and the increase of a measured distance $= \frac{\Delta f}{f} \cdot s$.

Thus for a heliometer of 63 inches focal length an error of 1 inch in the difference of r and f would only produce an error of 0″·0173 on an angle of 2°; hence it is exceedingly improbable that any sensible error can arise from this cause.

It is, however, interesting and important to examine whether this is really the case, and how far actual measures confirm this conclusion.

Table VII. gives the results of all the observations made on the zones at Mauritius; the details of the observations will be found p. 86 to p. 94. Not to enter for the present on the discussion of the effect of an abnormal focal adjustment, it will be convenient to employ only those measures made with the same focal point (8·05).

TABLE VII.

Name of objects	Date 1874	Focal point	Temperature	Distance in screw revolutions for 1874·0	Distance in arc, by approx. value of screw 1 R = 25″·729	Tabular distance from Table I.	c–o
Perseus zone *b–c*	Dec. 13	8·05	77° F.	104·3210	2684″·01	2684″·22	+0″·21
„ „ *e–f*	„ 3	...	74	[89·0315]			
„ „ *f–g*	„ 3	...	74	[111·2488]			
„ „ *g–h*	„ 3	...	74	[124·7708]			
„ „ *g–h*	„ 14	8·05	77	124·8834	3213·12	3213·33	+0·21
„ „ *h–i*	„ 2	8·15	74	86·5224	2226·13	2226·33	+0·20
„ „ *i–k*	„ 2	8·15	74	112·8998	2904·80	2904·58	−0·22
„ „ *c–e*	„ 13	8·05	77	198·0296	5095·10	5095·16	+0·06
„ „ *c–e*	„ 14	8·05	76	198·0265	5095·02	5095·16	+0·14
„ „ *e–g*	„ 13	8·05	77	196·7195	5061·40	5061·41	+0·01
(½ weight) *e–g*	„ 16	8·06	77	196·7372	5061·85	5061·41	−0·44
„ „ *h–k*	„ 13	8·05	77	188·2040	4842·30	4842·23	−0·07
„ „ *h–k*	„ 14	8·05	77	188·1850	4841·81	4842·23	+0·42
Hydra zone *a–b*	Dec. 21	8·05	74	93·2628	2399·56	2398·93	−0·63
„ „ *b–c*	„ 21	8·05	74	82·3390	2118·50	2118·17	−0·33
„ „ *c–d*	„ 21	8·05	76	85·4096	2197·50	2198·08	+0·58
„ „ *d–e*	„ 16	8·05	76	120·5213	3100·82	3101·19	+0·27
„ „ *e–f*	„ 14	8·05	75	74·0531	1905·31	1905·38	+0·07
„ „ *a–c*	„ 23	8·05	77	174·2587	4483·50	4482·96	−0·54
„ „ *c–e*	„ 26	8·05	77	204·8320	5270·12	5270·43	+0·31
„ „ *a–d*	„ 26	8·05	78	259·6577	6680·73	6679·34	−1·29
„ „ *d–f*	„ 22	8·05	76	190·6079	4904·15	4904·69	+0·44
„ „ *d–f*	„ 26	8·05	78	190·6262	4904·62	4904·69	+0·07
(½ weight) *c–f*	„ 24	8·05	77	275·9461	7099·82	7100·53	+0·71
„ „ *c–f*	„ 26	8·05	78	276·0079	7101·41	7100·53	+0·12

On December 3 the focal point seems not to have been noted, and the observations on that night have accordingly not been included. It has been shown by us already ('Monthly Notices of the Royal Astronomical Society,' vol. xxxiv. pp. 286–287) that the temperature coefficient of the heliometer is very small (about + 0″·0018 for + 1° and 1000″ distance).

The mean temperature is 77° F. throughout, the extreme difference −3°, which only occurs in two instances (Hydra zone *a–b* and *b–c*), for which the corrections amount to −0″·0043 and −0″·0038, quantities quite insignificant, and which are therefore neglected, especially as their determination is affected with a comparatively large probable error.

If the scale value is not uniform, we may suppose that any measured distance may be converted into arc by the formula

$$a\,s + b\,s^2,$$

where s is the distance measured in screw revolutions, and a and b are coefficients to be determined.

It is evident, from inspection of the residuals (c–o) in Table VII., that distances are very nearly represented by $a\,s$ alone, where $a = 25''{\cdot}729$; hence we may put

$$25{\cdot}729\,s + \frac{s}{10}\,a + b\,\frac{s^2}{100}\,b = \text{tabular distance},$$

where a represents the error of the adopted value 25·729 in 10 revolutions and b is taken for 100 revolutions.

Table VII. will thus furnish equations of the type

$$\frac{s}{10}a + \frac{s^2}{100}b = \text{C}-\text{O},$$

which are as follow :—

							w
(1)	Perseus zone	b–c	10·4 a + 1·08 b =	+ 0·21			31·9
(2)	„ „	c–e	19·8	3·92	+ 0·10		33·5
(3)	„ „	e–g	19·7	3·88	− 0·15		22·1
(4)	„ „	g–h	12·5	1·56	+ 0·21		25·9
(5)	„ „	h–k	18·8	3·53	+ 0·18		30·4
(6)	Hydra zone	a–b	9·3	0·86	− 0·63		21·9
(7)	„ „	b–c	8·2	0·67	− 0·33		16·1
(8)	„ „	c–d	8·5	0·72	+ 0·58		15·9
(9)	„ „	d–e	12·0	1·44	+ 0·27		13·9
(10)	„ „	e–f	7·4	0·55	+ 0·07		19·9
(11)	„ „	a–c	17·4	3·03	− 0·54		14·8
(12)	„ „	c–e	20·5	4·20	+ 0·31		10·3
(13)	„ „	a–d	26·0	6·76	− 1·29		10·5
(14)	„ „	d–f	19·1	3·64	+ 0·25		18·2
(15)	„ „	c–f	27·6	7·62	+ 0·36		12·8

The computation of the weights in the column w is greatly facilitated by Table V., from which

$$w = \frac{1}{(f' \times \epsilon_a)^2 + (f'' \times \epsilon_b)^2 + \frac{\epsilon^2}{n}},$$

where n is the number of observations of weight = 1, and the other values are taken directly from the table.

Multiplying each equation by $\sqrt{w}$, we obtain a series of equations from which, by the method of least squares, the resulting normal equations are—

For a . . . 16415 a + 3153 b = 22·26 ;
For b . . . 79729 a + 16015 b = 89·37 ;

whence

$$a = +\cdot 0556 ;$$

$$b = -\ 0''\cdot 280 \pm 0''\cdot 177.$$

This value of b is affected with a probable error greater than half its amount, and seems to depend for its presence chiefly on the equation (13) a–d, December 26, which appears to stand out from the other large distances conspicuously.

As far as the measures of Juno are concerned, it would make little difference whether we adopt this value of b or not; it has been considered more probable that the scale value is sensibly uniform for all angles.[1]

To deduce the value of a on this supposition the errors of the intermediate distances are not to be taken into account, the probable error of the zigzag distance being only increased by the amount due to probable error of the position angles.

[1] It will be afterwards found, in the method of reducing the observations of Juno, that we are only concerned to know exactly the distance traversed by the planet between the evening and morning observations which are compared for parallax. To take an extreme case, suppose the distance = 200 revolutions in the evening, and in the morning 220 revolutions ; the distance traversed by the formula just found would be 514″·579, and by the supposition that the screw value is, as finally adopted, 25″·728924, the distance traversed is 514″·578. The difference is insensible.

Thus for the Perseus zone we have—

		$\frac{e^2}{n}$
b–c . . .	$10{\cdot}4\,a = +0''{\cdot}21$	·015625
c–e . . .	$19{\cdot}8 = +0{\cdot}10$	·015305
e–g . . .	$19{\cdot}7 = -0{\cdot}15$	·037191
g–h . . .	$12{\cdot}5 = +0{\cdot}21$	·028683
h–k . . .	$18{\cdot}8 = +0{\cdot}18$	·024122
	$81{\cdot}2\,a = +0{\cdot}55$	$\Sigma\frac{e^2}{n} = {\cdot}120926$
b–k . . .	$(f' \times \epsilon_a)^2$	= ·004624
	$(f'' \times \epsilon_\delta)^2$	= ·002401
	ϵ_δ^2 ·127951	$\omega = \frac{1}{\epsilon_\delta^2}$ = 7·8

The Hydra zone having been measured in different ways, these different measures must be combined.

			$\frac{e^2}{n}$		
1 [1]	*a–b* . . .	$9{\cdot}3\,a = -0''{\cdot}63$	·014884		
	b–c . . .	$8{\cdot}2 = -0{\cdot}33$	·012769		
	c–d . . .	$8{\cdot}5 = +0{\cdot}58$	·013456		
	d–e . . .	$12{\cdot}0 = +0{\cdot}27$	·020449		
	* *e–f* . . .	$7{\cdot}4 = +0{\cdot}07$	·022898		
		$45{\cdot}4\,a = -0{\cdot}07$	$\Sigma\frac{e^2}{n}$ ·084456	$\omega = 11{\cdot}8$	$\sqrt{\omega} = 3{\cdot}44$
2 [1]	* *a–c* . . .	$17{\cdot}4\,a = -0{\cdot}54$	·068450		
	c–e . . .	$20{\cdot}5 = +0{\cdot}31$	·044100		
	* *e–f* . . .	$7{\cdot}4 = +0{\cdot}07$	·022898		
		$45{\cdot}3\,a = -0{\cdot}16$	$\Sigma\frac{e^2}{n}$ ·135448	$\omega = 7{\cdot}4$	$\sqrt{\omega} = 2{\cdot}73$
3 [1]	* *a–c* . . .	$17{\cdot}4\,a = -0{\cdot}54$	·068450		
	c–f . . .	$27{\cdot}6 = +0{\cdot}36$	·046113		
		$45{\cdot}0\,a = -0{\cdot}18$	$\Sigma\frac{e^2}{n}$ ·114563	$\omega = 8{\cdot}7$	$\sqrt{\omega} = 2{\cdot}95$
4	*a–d* . . .	$26{\cdot}0\,a = -1{\cdot}29$	·063001		
	d–f . . .	$19{\cdot}1 = +0{\cdot}25$	·023545		
		$45{\cdot}1\,a = -1{\cdot}04$	$\Sigma\frac{e^2}{2}$ ·086541	$\omega = 11{\cdot}5$	$\sqrt{\omega} = 3{\cdot}40$
				$\omega = 39{\cdot}4$	$\Sigma\sqrt{\omega} = 12{\cdot}52$

Multiplying each of the four preceding equations by $\frac{\sqrt{w}}{\Sigma\sqrt{w}}$, we get—

(1) × ·275 . . .	$12{\cdot}48\,a = -0{\cdot}019$	
(2) × ·218 . . .	$9{\cdot}88\,a = -0{\cdot}035$	
(3) × ·236 . . .	$10{\cdot}62\,a = -0{\cdot}042$	
(4) × ·271 . . .	$12{\cdot}22\,a = -0{\cdot}282$	
	$45{\cdot}20\,a = -0{\cdot}378$	W = 39·4
		ϵ^2 = ·025380
For *a–f* . . .	$(f' \times \epsilon_a)^2$ =	·000900
For *a–f* . . .	$(f'' \times \epsilon_\delta)^2$ =	·014941
	ϵ^2 = ·041221	$\frac{1}{\epsilon_\delta^2}$ = W = 24·3

[1] The pairs of stars marked *, it will be observed, are employed each twice; the value of $\frac{e^2}{n}$ is accordingly doubled on each occasion for these stars.

Thus we obtain finally—

From Perseus zone . . .	$81{\cdot}2\,a = +0{\cdot}55$	ω 7·8;
From Hydra zone . . .	$45{\cdot}2\,a = -0{\cdot}38$	ω 24·3.

Hence $$a = -0{\cdot}000757;$$

$$\text{and 1 revolution} = 25''{\cdot}729 + \frac{a}{10} = 25''{\cdot}728924.$$

For focal point, 8·05; temperature, 77° F.

We shall afterwards find in the discussion of the ultimate value of the scale to be adopted in the transit of Venus observations (when the Dun Echt observations are included), that the assumption that the scale value is really uniform is confirmed, and that the term dependent on the square of the distance really originates in the discordant observation *a–d* of the Hydra zone.

This is confirmed by the reply to a question addressed to Messrs. Repsold—namely, What is the largest error it is possible to suppose in the difference of the radius of motion and focal lengths of the object glass? and the answer was that, making all possible allowances for differences caused by grinding, the difference could not amount to more than two millimetres. Such an error could not, as we have shown, exercise any sensible influence on the difference of scale value.

As regards the absolute value of the scale in the following discussion of the observations of Juno, the above value has been adopted, and the accompanying table calculated from it, but the method of reduction adopted eliminates any error in this value, so that the final result does not depend at all on the investigation of the scale value. The scale value now found for focal point 8·05, and temperature 77°, will, however, play an important part in the discussion of the scale value in the transit of Venus observations.

The Position Angles.

The zero of the position circle is perfectly determined without regard to the errors of the equatorial adjustment, by rotating the tube upon the declination axis. If the declination axis remains immovable during this rotation, and if, during the rotation, the two images of a distant object produced by the separated segments successively bisect the cross webs in the focus of the eye-piece, then we know that the optical centres of the segments are in a plane at right angles to the declination axis, and the difference of the reading of the position circle from zero is its index error for that position of the tube and the segments. If we now reverse the position of the segments separating their optical centres by the same amount in the opposite direction, and again act on the position circle by small changes till the rotation of the tube causes the images of the distant point both to pass the intersection of the webs in the focus of the eye-piece, we get another determination of the zero of the position circle differing from the last by 2ψ. Where

$$\tan\psi = \frac{\mu}{\text{distance of separation of segments}},$$

and where μ is the want of coincidence of optical centres at least distance, see Chapter IV.

The mean of these two determinations will be free from the error produced by μ. and will give the true index correction provided there is no flexure of the declination axis, or tendency

of the cradle to twist about its point of attachment to the declination axis. This, however, cannot be assumed, and in order to measure the amount of flexure it is necessary to determine the index correction in more than one position. The most advantageous conditions are afforded by determining the index correction when the telescope is placed in the same horizontal direction in reversed positions of the declination axis, or in opposite directions in the same position of the declination axis. The following were the arrangements made to determine this important constant :—

Upon a strong pillar of masonry to the north of the instrument were mounted in cast-iron frames, capable of adjustment, two lenses each of about 300 feet focal length and 6 inches aperture. The lenses were so placed that when the tube of the telescope was directed north horizontally—the declination axis being horizontal—the optical axis of the telescope prolonged would pass approximately through the centre of a lens in either position of the instrument—that is, tube E or tube W. In the focus of these lenses were small azimuth marks, each consisting of a hole about ·03 inch in diameter, bored in a plate of platinum. The platinum plates were screwed to small cast-iron standards, and these were mounted on a solid pillar of masonry, so as to form each with its corresponding lens a true horizontal meridian mark.

These meridian marks were very useful for many purposes.

1. They enabled the determination of the index correction to be made conveniently at any time for either horizontal position of the declination axis.

2. From the distance between the lenses and the marks, and the great solidity of the rock-founded piers, their directions could be assumed constant as to level and azimuth ; hence they afforded a control at any moment on the azimuth and inclination of the polar axis.

3. By means of a few additional holes bored in the platinum plates, artificial double stars for determining accurately the quantity μ were available, at any time and in any weather.

To detect possible motion of the declination axis during rotation of the tube on the axis, a striding level was applied to the truly turned collars $\pi\,\pi$ on the declination axis. It was not, of course, necessary that the declination axis should be absolutely level, only that any change of level during the rotation should be detected and corrected.

The tables at the end of this chapter exhibit the observations which were actually thus made to determine the zero of the position circle.

On December 4, the rotation of the instrument having become somewhat difficult, the 'damping rings' were taken off, the telescope was withdrawn to some extent from the cradle, and the bearings were cleaned and oiled.

We may therefore divide the position circle zero determinations into two periods, those before and those after December 4.

They give—

1874		Telescope	Distance in scale divisions	Number of complete observations	Weight
November 27 . . .	+ 3′·25	East	10	1	1
November 28 . . .	+ 2·78	„	10	4	4
December 1 . . .	+ 3·11	„	20	3	6

Mean having regard to weight + 3′·00 for telescope east—that is, star west.

That is, before December 4.

Correction for index error = 0° 3′·0 for observation W. of meridian.

The results of December 5 give similarly, with considerable weight—

Correction for Obs. W.	Correction for Obs. E.
− 4′·60	− 3′·59

There would therefore appear to be a small change of index error caused by the removal of the tube, and also sensible twisting of the cradle about its point of support, amounting at its maximum to + and − 0′·5.

The pressure of much work and many different duties prevented more frequent determinations being made, and indeed a little experience showed that the zero of the position circle could be determined much more easily and accurately from observations of pairs of otherwise well-determined stars, for the obvious reason that the two stars are seen simultaneously, and thus the observation is free from possible change of position of the declination axis during rotation, and also—what is no less important—is free from the tediousness of any method which involves successive approximations by trial and error.

Another very important advantage of the method by means of stars is that, if the standard determining stars are selected near the place of the stars whose position angle it is desired to measure, the determination of the index error will include the error due to errors in the equatorial adjustment of the instrument.

The construction of Lord Lindsay's heliometer is somewhat deficient in this respect, that the declination circle has only one vernier, and reads only to single minutes of arc. There is strong evidence in the exact agreement of the determinations of the altitude of the pole by different stars to show that there is no sensible eccentricity, and the accompanying observations (p. 131) of stars E. and W. of the meridian show that within the limits of the reading of the circle the equatorial adjustment is nearly perfect.

In the excellent instructions drawn up by Auwers and Winnecke for observing the transit of Venus by means of the heliometer, a list of stars is given nearly of the same declination as the sun on the morning of the transit. Believing that the places of these stars would be rigidly determined by meridian observations, the position angles of some of these stars were carefully observed (see observations, pp. 86–89), with the following results :—

τ^6 AND τ^7 ERIDANI.

1874	Hour angle	Position angle, without index corr.	Reduction to 1874·0	Corr. for proper motion to 1874·0	Resulting position angle, without index corr.	Factors
	hrs. mins.	° ′	′		° ′	
December 1 . .	21 5	163 53·11	0·00	unknown	163 53·11	+ 0·06
„ 4 . .	2 0	53·51	− 0·01	„	53·50	− 0·01
„ 6 . .	21 30	53·30	− 0·01	„	53·29	+ 0·04

ξ^1 AND ξ^2 CAN. MAJ.

	hrs. mins.	° ′	′		° ′	
December 1 . .	23 35	57 36·69	− 0·16	unknown	57 36·53	− 0·03
„ 4 . .	23 32	36·98	− 0·16	„	36·82	− 0·03
„ 6 . .	19 30	36·80	− 0·17	„	36·63	+ 0·10

11 AND 12 PUPPIS. (B. A. C., 2652 and 2662.)

	hrs. mins.	° ′	′		° ′	
December 1 . .	19 50	129 18·63	− 0·22	unknown	129 18·41	+ 0·16
„ 6 . .	18 30	19·10	− 0·21	„	18·89	+ 0·27

If we suppose, with Bessel, that the difference of index correction found in the collimator

determinations, tube E and tube W, is due to a *twist* round the point of attachment to the declination axis, from want of absolute rigidity in the materials, then the amount of this twist will be proportional to the force by which it is produced.

This force will obviously attain a maximum when the declination axis and the heliometer axis are both horizontal; the whole effective weight of tube and cradle will then act in an axis in the plane of the position circle.

The effective weight along this axis for any other position will vary as the cos of the zenith distance of that axis; therefore, to find the coefficient of flexure for any position of the instrument, we have only to find the zenith distance of the axis in question.

Since the total flexure is always small, and the errors of adjustment of the equatorial are also small, we may consider the instrumental and the astronomical directions alike in determining the coefficient of flexure. The axis in question has the same hour angle as the heliometer axis, and a declination $= 90^\circ + \delta$; hence for any star whose declination is δ, hour angle τ, and plane whose latitude is ϕ, we have

$$\cos \text{ZD} . = \sin \phi \cos \delta - \cos \phi \sin \delta \cos \tau,$$

and the flexure for any object $f_1 = f(\sin \phi \cos \delta - \cos \phi \sin \delta \cos \tau)$.

Computing for the observations of the position-angle stars, the factors in question, we find them as entered in the last column of the table.

The small differences of these factors show that flexure can produce little sensible effect, and the agreement of the observations at different hour angles shows that the errors of the equatorial adjustment are at least so small as to produce but trifling changes during a considerable range of hour angle.

Since in the transit of Venus observations it is sufficient to know the index error with an accuracy of 1′, these observations are amply sufficient if only a good determination of the places of these stars is made.

For the Juno observations no considerable accuracy in this determination is required, as when two opposite stars of comparison are employed the correction of the index error of the positive circle must be considered an unknown quantity, both for the morning and evening, so that if the absolute places of the stars of comparison are well determined we have from these observations independent determinations of the index error.

On three nights such complete determinations were made.

The observations give—

1874	Resulting corr. for star E.	Resulting corr. for star W.	W−E
November 15, evening and morning . . .	−2′·65	−4·16	−1′·51
November 18, morning, and 19, evening . .	−3·07	−4·64	−1·57
November 23, evening, and 24, morning . .	−3·16	−4·94	−1·78
Mean . . .	−3·04	−4·58	

It must be remembered that these discordances include errors in the determinations of the places of the stars of comparison, as well as possible change in the zero of the position circle.

We eliminate the error of the star places, and perhaps part of the possible errors produced by change of zero, by taking the difference of the index corrections E. and W. determined by the same stars.

These give the very accordant values W–E of the last column, which are entirely satisfactory, seeing that the vernier only reads to 0′·50.[1]

In the preliminary reduction of the observations of Juno a uniform index correction of − 3′·00 has been applied to all readings of the position circle, and in the after calculations the terms E and W in the position-angle equations (which express the corrections required to the assumed index correction) have been taken − 0′·04 and − 1′·58 respectively, where only one star is observed, and these include a very small correction for eccentricity, since the position angle was determined by the vernier when E., and by another when W., and also the errors due to the equatorial adjustment. For the transit of Venus reductions it is obviously safe to assume an index correction of − 3′·0, and this is made more certain by reference to the observations of the Hydra zone given below, together with those of the Perseus zone.

These assumptions are probably far more satisfactory than any attempt would be to deduce the errors of the equatorial adjustment from the materials deduced from the declinations of stars; and since the whole error introduced in any of the observations due to this cause cannot amount to 0′·5 in the position angles, it is of no consequence in any of the following discussions, which depend entirely on the distances.

Date, 1874	Stars	Observed position angle	Correction to Jan. 1	Proper motion	Corrected to 1874·0 without index correction	Tabular position angle	Apparent index correction	Hour angle
								h. m.
Dec. 21	*a–b*	171° 23′·05	−0′·30	−0′·13	171° 22′·62	171° 20′·15	−2′·47	22 30
„ 21	*b–c*	157 17·16	−0·31	+0·14	157 16·99	157 12·56	−4·43	21 40
„ 21	*c–d*	162 1·40	−0·31	−0·29	162 0·80	161 57·79	−3·03	20 30
„ 16	*d–e*	149 52·41	−0·31	+0·19	149 52·41	149 49·06	−3·35	19 35
„ 16	*e–f*	173 43·18	+0·25	−0·26	173 43·17	173 40·09	−3·08	20 40
½ obs. „ 26	*a–d*	163 52·35	−0·31	−0·10	163 51·94	163 48·46	−3·48	21 35
„ 22	*d–f*	158 55·31	−0·32	+0·11	158 51·10	158 51·40	−3·70	20 30
„ 23	*a–c*	164 46·63	−0·31	−0·07	164 46·25	164 42·80	−3·45	20 17
½ obs. „ 24	*c–f*	159 53·92	−0·32	−0·01	159 53·59	159 48·99	−4·60	1 40
„ 26	*c–f*	159 52·43	−0·32	−0·01	159 52·10	159 48·99	−3·11	19 40
„ 26	*c–e*	154 55·16	−0·32	−0·00	154 54·84	154 51·00	−3·84	21 20
Perseus Zone, Position Angles								
Dec. 13	*b–c*	46 26·87	−0·36	−0·06	46 26·45	46 21·86	−4·59	22 50
„ 13	*c–e*	56 35·20	−0·38	+0·11	56 34·93	56 30·86	−4·07	21 55
„ 3	*e–f*	92 31·63	−0·34	−0·13	92 31·16	92 27·26	−3·90	23 10
„ 3	*f–g*	70 9·21	−0·33	+0·03	70 8·91	70 5·08	−3·83	22 20
„ 3	*g–h*	71 30·13	−0·32	+0·07	71 29·88	71 26·12	−3·76	21 35
„ 14	*g–h*	71 31·12	−0·31	+0·08	71 30·79	71 26·12	−4·67	23 30
„ 2	*h–i*	87 47·95	−0·31	+0·03	87 47·67	89 17·31	...	...
„ 2	*i–k*	48 22·42	−0·30	−0·21	48 21·91	...	...	...
„ 14	*c–e*	56 35·56	−0·34	+0·11	56 35·33	56 30·86	−4·47	0 15
„ 13	*e–g*	79 6·32	−0·32	−0·06	80 5·94	80 1·20	−4·74	23 45
„ 13	*h–k*	65 25·91	−0·3[illegible]	−0·05	65 25·53	65 20·58	−4·95	1 0
„ 14	*h–k*	65 25·30	−0·2[illegible]	−0·05	65 25·30	65 20·58	−4·72	22 30

[1] This value of W–E is confirmed by th[illegible]bs[illegible]ations of *c–f* Hydra zone on December 24 and 26, which give W–E = + 1′·49.

Determinations of Zero of Position Circle by Collimators.

November 27. Telescope East.

	I.	II.	App. index error	Mean error	
	° ′	° ′	′	′	′
Scale A 85	0 9·5	180 9·0	+ 9·25	+2·75	+3·25
„ B 84	359 56·5	179 56·0	− 3·75		
Scale B 84	179 56·0	359 56·5	− 3·75	+3·75	
„ A 85	180 11·5	0 11·0	+11·25		

November 28.

Scale A 85	180 12·5	0 11·5	+13·50	+1·44	+2·53
	10·5	9·5			
	16·5	15·5			
	16·5	15·5			
Scale B 84	179 47·0	359 46·5	−10·62		
	50·0	49·5			
	50·0	49·0			
	52·0	51·0			
Scale B 84	359 52·5	179 52·0	−10·25	+3·63	
	47·0	46·5			
	48·5	48·0			
	52·0	51·5			
Scale A 85	0 20·0	180 19·5	+17·50		
	17·5	16·5			
	16·5	16·0			
	17·5	16·5			

December 1.

Scale A 95	0 6·5	180 6·0	+ 6·42	+2·58	+3·11
	5·0	4·5			
	8·5	8·0			
Scale A 55	359 59·5	179 59·0	− 1·25		
	58·5	58·0			
	58·5	58·0			
	59·5	59·0			
Scale A 55	180 0·0	0 0·5	− 0·08	+3·65	
	179 59·5	359 59·5			
	180 0·0	0 0·0			
Scale A 95	180 8·0	0 7·5	+ 7·37		
	6·5	5·5			
	8·5	7·5			
	8·0	7·5			

December 5, 1874. On East Collimator, pointing North.

Scale A 105	180 8·00	0 7·50	+ 8·00	+4·50	+4·60
	8·50	8·00			
Scale A 45	180 1·50	1·00	+ 1·00		
	1·00	0·50			
Scale A 45	0 0·00	179 59·75	+ 0·56	+4·69	
	1·50	180 1·00			
Scale A 105	0 9·25	180 9·00	+ 8·81		
	8·75	8·25			

DETERMINATIONS OF ZERO OF POSITION CIRCLE BY COLLIMATORS—*continued.*

ON WEST COLLIMATOR, POINTING NORTH.

	I.	II.	App. index error	Mean error	
	° ′	° ′	′	′	′
Scale A 105	0 5·25	180 5·50	+ 5·63		
	5·75	6·00		+4·07	
Scale A 45	0 2·25	180 2·50	+ 2·50		
	2·50	2·75			+3·59
Scale A 45	180 0·25	0 0·50	+ 1·25		
	2·00	2·25		+3·10	
Scale A 105	180 4·75	5·00	+ 4·94		
	5·00	5·00			

These observations were made with the greatest care not only to find the zero of the position circle, but also the effect of flexure on the position angles.

On December 4, the rotation of the instrument in the cradle having been found difficult, the telescope was withdrawn to some extent from the cradle, and the bearings were cleaned and oiled.

Previous to December 4 we have determinations of the position-circle zero.

November 27 . .	Correction − 3′·25	East collimator, distance 10 divisions	1 complete observation	
November 28 . .	,, − 2·78	,, ,, 10 ,,	4 ,,	observations
December 1 . .	,, − 3·11	,, ,, 20 ,,	3 ,,	,,

Attaching weights proportional to the distance and number of observations, we have

November 27 . . .	Correction	− 3′·25 × 1	= − 3·25
,, . . .	,,	− 2·78 × 4	= − 11·12
,, . . .	,,	− 3·11 × 6	= − 18·66
		11	= 33·03

Correction previous to December 4 = − 3′·00 for collimator east.

CHAPTER VIII.

TABULAR DISTANCES, POSITION ANGLES, AND FACTORS FOR JUNO, RELATIVE TO STARS OF COMPARISON.

THE steps followed in the reduction of the observations have been as follow :—

(1) The tabular places of Juno were computed for each five minutes of Greenwich sidereal time during the intervals embraced by the observations.

The method of computation and the resulting places will be found at p. 136, &c. (Table I.)

(2) By the kind permission of Dr. Ball, Astronomer Royal for Ireland, the stars of comparison were observed with the Dunsink transit circle by Dr. Copeland. The resulting places will be found at p. 141, &c. (Table II.), together with the constants for facilitating the computation of apparent place.

(3) The errors of the observing chronometer (sidereal 43) were determined by comparison with the standard sidereal chronometer (E.C.), the error of which was determined by means of observations in the meridian with the reversing transit by Dr. Copeland.

The *corrections* of the standard chronometer so determined are given at p. 144 (Table III.)

The comparisons made between (E.C.) and (43) are given at p. 145 (Table IV.)

The derived corrections of the observing chronometer are given in a convenient form (Table V.)

(4) Table VI. was then constructed as follows :—

Column 1 contains the number of groups, the date, and name of star compared with the planet.

Column 2. The rotation number of the observation.

„ 3. The observed time by the chronometer.

„ 4. Local sidereal time, derived by application of the correction from Table V.

„ 5. Greenwich sidereal time, derived by adding the approximate longitude—3 h. 50 min. 50 sec.—to the local sidereal time.

Column 6. The apparent $\mathcal{R}$ of the star of comparison (in arc), calculated rigidly from the data of Table II., for the mean epoch of the group.

Column 7. The apparent declination of the star of comparison, similarly calculated for the mean epoch of each group.

Column 8. The geocentric $\mathcal{R}$ of the planet = tabular $\mathcal{R}$ for the epoch, arg. Greenwich sidereal time, from Table I. + 2′.

(This correction of + 2′ is nearly the mean correction required by the tables during the series of observations.)

Column 9. The geocentric declination from Table I. + 15″.

Column 10. The parallax in $\mathcal{A}$R computed for geographical latitude $-20^\circ\ 2'$; mean solar parallax assumed, $8''{\cdot}85$.

Column 11. The parallax in declination.

„ 12. The apparent distance in arc between the planet and star computed from the tabular place of the planet (columns 8 and 9), corrected for parallax (columns 10 and 11), and the apparent place of the star (columns 6 and 7).

Column 13. The parallax factor in distance (f'''), or the effect on the distance of increasing the parallax $\frac{1}{100}$th part.

Column 14. The distance factor for change of $\mathcal{A}$R (f'), or the effect on the distance of increasing the $\mathcal{A}$R of the planet by $1''$.

Column 15. The distance factor for change of declination (f''), or the effect on the distance of increasing the N. declination of the planet by $1''$.

Column 16. The apparent position angle of the planet relative to the star computed from the place of the planet, corrected for parallax, and the apparent place of the star.

Column 17. The parallax factor in position angle ($f_{,,,}$), or the effect on this position angle of increasing the parallax $\frac{1}{100}$th part.

Column 18. The position-angle factor in $\mathcal{A}$R ($f_{,}$), or the effect on the position angle of increasing the $\mathcal{A}$R of the planet by $1''$.

Column 19. The position-angle factor in declination ($f_{,,}$), or the effect on the position angle of increasing the N. declination of the planet by $1''$.

TABLE I.—OPPOSITION OF JUNO, 1874.

TABULAR GEOCENTRIC R.A. AND DEC. OF PLANET FOR EVERY 5 MINUTES.

GREENWICH SIDEREAL TIME.

1874, November. Day, hour, and minute*	Tabular geocentric R.A.	Tabular geocentric Dec.	1874, November. Day, hour, and minute*	Tabular geocentric R.A.	Tabular geocentric Dec.	1874, November. Day, hour, and minute*	Tabular geocentric R.A.	Tabular geocentric Dec.
d. h. m.	° ′ ″	° ′ ″	d. h. m.	° ′ ″	° ′ ″	d. h. m.	° ′ ″	° ′ ″
10 19 20	45 2 46·55	−4 30 22·79	10 20 55	45 2 4·68	−4 30 54·40	10 3 50	44 59 1·86	−4 33 11·37
25	44·35	24·45	21 0	2·48	56·06	3 55	58 59·65	13·01
30	42·15	26·12	5	2 0·27	57·72	4 0	57·45	14·65
35	39·94	27·79	10	1 58·07	30 59·38	5	55·25	16·29
40	37·74	29·45	15	55·87	31 1·04	10 4 10	44 58 53·05	−4 33 17·93
45	35·54	31·11	10 21 20	45 1 53·66	−4 31 2·70			
50	33·33	32·78				11 18 20	44 52 39·28	−4 37 52·81
19 55	31·12	34·45	10 2 50	44 59 28·27	−4 32 51·68	25	37·09	54·41
20 0	28·92	36·11	2 55	26·07	53·32	30	34·90	56·00
5	26·71	37·78	3 0	23·87	54·96	35	32·70	57·60
10	24·51	39·44	5	21·66	56·60	40	30·50	37 59·19
15	22·31	41·10	10	19·46	58·24	45	28·31	38 0·78
20	20·10	42·77	15	17·26	32 59·88	50	26·11	2·38
25	17·90	44·43	20	15·06	33 1·53	18 55	23·91	3·98
30	15·70	46·09	25	12·86	3·17	19 0	21·72	5·57
35	13·49	47·76	30	10·66	4·81	5	19·52	7·16
40	11·29	49·42	35	8·46	6·45	10	17·32	8·75
45	9·09	51·08	40	6·26	8·09	15	15·13	10·34
10 20 50	45 2 6·88	−4 30 52·74	10 3 45	44 59 4·06	−4 33 9·73	11 19 20	44 52 12·93	−4 38 11·94

* The hours and minutes are in Greenwich sidereal time.

TABLE I.—TABULAR GEOCENTRIC R.A. AND DEC. OF JUNO—*continued.*

1874, November. Day, hour, and minute*	Tabular geocentric R.A.	Tabular geocentric Dec.	1874, November. Day, hour, and minute*	Tabular geocentric R.A.	Tabular geocentric Dec.	1874, November. Day, hour, and minute*	Tabular geocentric R.A.	Tabular geocentric Dec.
d. h. m.	° ′ ″	° ′ ″	d. h. m.	° ′ ″	° ′ ″	d. h. m.	° ′ ″	° ′ ″
11 19 25	44 52 10·74	−4 38 13·53	12 2 0	44 38 48·27	−4 47 40·23	13 3 15	44 27 51·83	−4 55 1·18
30	8·55	15·12	5	46·09	41·72	20	49·67	2·60
35	6·35	16·71	10	43·91	43·21	25	47·51	4·01
40	4·15	18·30	15	41·74	44·71	30	45·36	5·42
45	52 1·96	19·89	20	39·56	46·20	35	43·20	6·84
50	51 59·76	21·49	25	37·38	47·70	40	41·05	8·25
19 55	57·57	23·08	12 2 30	44 38 35·21	−4 47 49·19	45	38·90	9·66
20 0	55·38	24·67				50	36·74	11·08
5	53·18	26·27	13 18 20	44 31 42·87	−4 52 28·30	3 55	34·58	12·49
11 20 10	44 51 51·98	−4 38 27·86	25	40·71	29·74	4 0	32·43	13·90
			30	38·55	31·18	5	30·27	15·32
12 18 20	44 42 8·79	−4 45 21·47	35	36·38	32·63	13 4 10	44 27 28·12	−4 55 16·73
25	6·61	22·99	40	34·22	34·07			
30	4·43	24·51	45	32·06	35·51	14 3 0	44 17 40·96	−5 1 33·24
35	2·24	26·03	50	29·89	36·96	5	38·83	34·58
40	42 0·06	27·55	18 55	27·73	38·40	10	36·70	35·92
45	41 57·88	29·07	19 0	25·57	39·84	15	34·57	37·25
50	55·69	30·59	5	23·41	41·28	20	32·44	38·59
18 55	53·51	32·11	10	21·25	42·72	25	30·31	39·92
19 0	51·33	33·63	15	19·09	44·16	30	28·18	41·25
5	49·15	35·15	20	16·92	45·60	35	26·05	42·59
10	46·97	36·67	25	14·76	47·04	40	23·92	43·92
15	44·79	38·18	30	12·60	48·47	45	21·79	45·25
20	42·61	39·70	35	10·43	49·91	50	19·66	46·59
25	40·43	41·22	40	8·27	51·35	3 55	17·53	47·93
30	38·25	42·73	45	6·11	52·79	4 0	15·40	49·26
35	36·06	44·25	50	3·94	54·23	5	13·27	50·60
40	33·88	45·77	19 55	31 1·78	55·67	10	11·14	51·93
45	31·70	47·28	20 0	30 59·62	57·11	15	9·01	53·26
50	29·52	48·80	5	57·46	58·55	14 4 20	44 17 6·88	−5 1 54·60
19 55	27·34	50·32	13 20 10	44 30 55·30	−4 52 59·98			
20 0	25·16	51·83				15 19 50	44 10 32·49	−5 5 57·70
5	22·97	53·35	13 2 0	44 28 24·16	−4 54 39·94	19 55	30·38	5 58·98
10	20·79	54·86	5	22·00	41·36	20 0	28·27	6 0·26
15	18·61	56·37	10	19·85	42·78	5	26·16	1·54
20	16·43	57·89	15	17·70	44·19	10	24·05	2·82
25	14·25	45 59·40	20	15·54	45·61	15	21·94	4·09
12 20 30	44 41 12·07	−4 46 0·91	25	13·38	47·03	20	19·83	5·37
			30	11·23	48·44	25	17·72	6·65
12 1 20	44 39 5·68	−4 47 28·25	35	9·07	49·86	30	15·61	7·93
25	3·50	29·75	40	6·91	51·28	35	13·50	9·21
30	39 1·33	31·24	45	4·76	52·69	40	11·39	10·49
35	38 59·15	32·74	50	2·60	54·11	45	9·28	11·77
40	56·97	34·24	2 55	28 0·44	55·53	50	7·17	13·05
45	54·80	35·73	3 0	27 58·29	56·94	20 55	5·06	14·33
50	52·62	37·23	5	56·13	58·36	21 0	2·95	15·60
12 1 55	44 38 50·44	−4 47 38·73	13 3 10	44 27 53·98	−4 54 59·77	15 21 5	44 10 0·84	−5 6 16·88

* The hours and minutes are in Greenwich sidereal time.

TABLE I.—TABULAR GEOCENTRIC R.A. AND DEC OF JUNO—*continued.*

1874, November. Day, hour, and minute*	Tabular geocentric R.A.	Tabular geocentric Dec.
d. h. m.	° ′ ″	° ′ ″
15 21 10	44 9 58·73	−5 6 18·16
15	56·62	19·43
20	54·51	20·71
25	52·40	21·99
30	50·29	23·26
35	48·18	24·54
15 21 40	44 9 46·07	−5 6 25·81
15 1 30	44 8 9·18	−5 7 24·19
35	7·07	25·46
40	4·97	26·72
45	2·87	27·98
50	8 0·76	29·25
1 55	7 58·66	30·51
2 0	56·56	31·77
5	54·45	33·03
10	52·35	34·29
15	50·25	35·55
20	48·14	36·81
25	46·04	38·07
30	43·94	39·33
35	41·83	40·59
40	39·73	41·84
45	37·63	43·10
50	35·52	44·36
2 55	33·42	45·62
3 0	31·32	46·88
5	29·21	48·14
10	27·11	49·40
15	25·01	50·65
20	22·91	51·91
25	20·81	53·17
30	18·71	54·42
35	16·61	55·68
40	14·51	56·94
45	12·41	58·19
50	10·31	7 59·45
3 55	8·21	8 0·71
4 0	6·11	1·96
5	4·01	3·21
10	7 1·91	4·46
15	6 59·81	5·71
15 4 20	44 6 57·70	−5 8 6·96
17 19 10	43 50 51·53	−5 17 20·73
15	49·51	21·85
17 19 20	43 50 47·46	−5 17 22·98
17 19 25	43 50 45·42	−5 17 24·10
30	43·38	25·22
35	41·33	26·34
40	39·29	27·46
45	37·25	28·58
50	35·20	29·71
19 55	33·16	30·83
20 0	31·12	31·95
5	29·07	33·07
17 20 10	43 50 27·03	−5 17 34·19
18 19 0	43 41 12·39	−5 22 30·42
5	10·38	31·46
10	8·37	32·50
15	6·37	33·54
20	4·36	34·58
25	2·36	35·62
30	41 0·36	36·66
35	40 58·35	37·70
18 19 40	43 40 56·35	−5 22 38·74
18 1 30	43 38 36·45	−5 23 50·86
35	34·45	51·88
40	32·46	52·90
45	30·47	53·92
50	28·47	54·94
1 55	26·48	55·96
2 0	24·49	56·98
5	22·49	58·00
10	20·50	23 59·01
15	18·51	24 0·03
20	16·52	1·05
25	14·53	2·07
30	12·54	3·09
35	10·54	4·10
40	8·55	5·12
45	6·56	6·14
50	4·57	7·16
2 55	2·58	8·17
3 0	38 0·59	9·19
5	37 58·60	10·20
10	56·61	11·22
15	54·62	12·23
20	52·63	13·25
25	50·64	14·26
30	48·65	15·27
18 3 35	43 37 46·67	−5 24 16·29
18 3 40	43 37 44·69	−5 24 17·30
45	42·71	18·31
18 3 50	43 37 40·73	−5 24 19·32
19 19 40	43 31 25·53	−5 27 26·50
45	23·57	27·46
50	21·61	28·42
19 55	19·65	29·38
20 0	17·69	30·34
5	15·73	31·30
10	13·77	32·26
15	11·81	33·21
20	9·85	34·16
25	7·90	35·12
30	5·94	36·07
35	3·98	37·03
40	2·02	37·98
45	31 0·06	38·93
50	30 58·11	39·89
20 55	56·15	40·84
21 0	54·19	41·79
5	52·24	42·75
10	50·28	43·70
15	48·32	44·65
20	46·37	45·61
25	44·41	46·56
19 21 30	42 30 42·45	−5 27 47·51
20 19 10	43 22 19·45	−5 31 45·33
15	17·54	46·20
20	15·62	47·08
25	13·71	47·95
30	11·80	48·83
35	9·88	49·71
40	7·97	50·59
45	6·06	51·46
50	4·15	52·34
19 55	2·24	53·22
20 0	22 0·33	54·09
5	21 58·42	54·97
10	56·51	55·84
15	54·60	56·71
20	52·69	57·59
25	50·78	58·46
20 20 30	43 21 48·87	−5 31 59·33
20 2 10	43 19 39·37	−5 32 58·03

* The hours and minutes are in Greenwich sidereal time.

TABLE I.—TABULAR GEOCENTRIC R.A. AND DEC. OF JUNO—*continued.*

1874, November. Day, hour, and minute*	Tabular geocentric R.A.	Tabular geocentric Dec.	1874, November. Day, hour, and minute*	Tabular geocentric R.A.	Tabular geocentric Dec.	1874, November. Day, hour, and minute*	Tabular geocentric R.A.	Tabular geocentric Dec.
d. h. m.	° ′ ″	° ′ ″	d. h. m.	° ′ ″	° ′ ″	d. h. m.	° ′ ″	° ′ ″
20 2 15	43 19 37·47	−5 32 58·88	24 19 40	42 47 29·23	−5 45 29·95	25 20 55	42 39 7·66	−5 48 2·56
20	35·57	32 59·74				21 0	6·04	3·02
25	33·67	33 0·59	24 1 40	42 45 28·23	−5 46 8·57	5	4·42	3·48
30	31·78	1·44	45	26·56	9·09	25 21 10	42 39 2·80	−5 48 3·94
35	29·88	2·30	50	24·88	9·62			
40	27·98	3·15	1 55	23·21	10·15	25 1 50	42 37 32·35	−5 48 29·27
45	26·09	4·00	2 0	21·54	10·67	1 55	30·74	29·72
50	24·19	4·86	5	19·86	11·20	2 0	29·14	30·16
2 55	22·29	5·71	10	18·19	11·72	5	27·53	30·61
3 0	20·40	6·56	15	16·52	12·24	10	25·92	31·05
5	18·50	7·41	20	14·85	12·77	15	24·32	31·49
10	16·60	8·26	25	13·18	13·29	20	22·71	31·93
15	14·71	9·11	30	11·51	13·81	25	21·10	32·37
20	12·81	9·96	35	9·84	14·34	30	19·50	32·81
25	10·92	10·81	40	8·17	14·86	35	17·89	33·25
20 3 30	43 19 9·03	−5 33 11·66	45	6·50	15·38	40	16·28	33·69
			50	4·83	15·91	45	14·68	34·13
23 19 20	42 55 51·34	−5 42 38·14	2 55	3·16	16·43	50	13·07	34·57
25	49·59	38·77	3 0	45 1·49	16·95	2 55	11·46	35·01
30	47·84	39·40	5	44 59·82	17·47	3 0	9·86	35·45
35	46·09	40·03	10	58·15	17·99	5	8·25	35·89
40	44·34	40·66	15	56·48	18·51	10	6·64	36·33
45	42·59	41·29	20	54·82	19·03	15	5·04	36·77
50	40·84	41·92	25	53·15	19·55	20	3·43	37·21
19 55	39·09	42·55	30	51·48	20·07	25	1·83	37·65
20 0	37·34	43·18	35	49·82	20·59	30	37 0·23	38·09
5	35·59	43·80	40	48·15	21·11	35	36 58·62	38·53
10	33·84	44·43	45	46·48	21·63	25 3 40	42 36 57·02	−5 48 38·97
15	32·09	45·06	24 3 50	42 44 44·81	−5 46 22·15			
20	30·35	45·69				26 19 30	42 31 56·53	−5 49 57·11
25	28·60	46·31	25 19 30	42 39 35·26	−5 47 54·68	35	54·97	57·50
30	26·85	46·94	35	33·63	55·15	40	53·41	57·88
35	25·11	47·57	40	32·00	55·62	45	51·85	58·26
40	23·36	48·20	45	30·38	56·08	50	50·29	58·65
45	21·61	48·82	50	28·75	56·55	19 55	48·73	59·03
50	19·86	49·45	19 55	27·13	57·01	20 0	47·18	59·41
20 55	18·12	50·08	20 0	25·51	57·47	5	45·62	49 59·80
21 0	16·37	50·70	5	23·88	57·94	10	44·06	50 0·18
5	14·62	51·32	10	22·26	58·40	15	42·51	0·55
10	12·87	51·95	15	20·64	58·86	20	40·95	0·94
15	11·13	52·77	20	19·01	59·33	25	39·39	1·32
23 21 20	42 55 9·38	−5 42 53·19	25	17·39	47 59·79	30	37·84	1·70
			30	15·77	48 0·25	35	36·28	2·08
24 19 20	42 47 35·99	−5 45 27·76	35	14·14	0·72	40	34·72	2·46
25	34·30	28·31	40	12·52	1·18	45	33·17	2·84
30	32·61	28·85	45	10·90	1·64	50	31·61	3·22
24 19 35	42 47 30·92	−5 45 29·40	25 20 50	42 39 9·28	−5 48 2·10	26 20 55	42 31 30·06	−5 50 3·60

* The hours and minutes are in Greenwich sidereal time.

TABLE I.—TABULAR GEOCENTRIC R.A. AND DEC. OF JUNO—*continued.*

1874, November. Day, hour, and minute*	Tabular geocentric R.A.	Tabular geocentric Dec.	1874, November. Day, hour, and minute*	Tabular geocentric R.A.	Tabular geocentric Dec.	1874, November. Day, hour, and minute*	Tabular geocentric R.A.	Tabular geocentric Dec.
d. h. m.	° ′ ″	° ′ ″	d. h. m.	° ′ ″	° ′ ″	d. h. m.	° ′ ″	° ′ ″
26 21 0	42 31 28·50	−5 50 3·98	27 19 40	42 24 34·45	−5 51 36·68	29 2 25	42 9 10·40	−5 53 54·98
			45	32·96	36·98	30	9·08	55·09
26 1 50	42 29 58·71	−5 50 25·50	50	31·47	37·29	35	7·76	55·21
1 55	57·17	25·86	19 55	29·98	37·59	40	6·44	55·33
2 0	55·63	26·22	20 0	28·49	37·89	45	5·12	55·45
5	54·09	26·59	5	27·00	38·20	50	3·80	55·57
10	52·55	26·95	27 20 10	42 24 25·51	−5 51 38·50	2 55	2·48	55·69
15	51·01	27·31				3 0	9 1·16	55·80
20	49·47	27·67	28 2 0	42 15 48·84	−5 53 8·20	5	8 59·84	55·92
25	47·93	28·03	5	47·44	8·40	10	58·52	56·04
30	46·39	28·39	10	46·04	8·60	15	57·20	56·15
35	44·85	28·75	15	44·65	8·80	20	55·88	56·27
40	43·31	29·11	20	43·25	9·00	25	54·56	56·39
45	41·77	29·47	25	41·86	9·20	29 3 30	42 8 53·25	−5 53 56·50
50	40·24	29·83	30	40·46	9·39			
2 55	38·70	30·19	35	39·06	9·59	30 20 10	42 4 35·00	−5 54 14·04
3 0	37·16	30·55	40	37·67	9·79	15	33·74	14·10
5	35·62	30·91	45	36·27	9·99	20	32·47	14·16
10	34·08	31·27	50	34·87	10·19	25	31·21	14·22
15	32·55	31·62	2 55	33·48	10·39	30	29·95	14·27
20	31·01	31·98	3 0	32·08	10·58	35	28·68	14·33
25	29·47	32·34	5	30·69	10·78	40	27·42	14·39
30	27·94	32·70	10	29·29	10·98	45	26·16	14·45
35	26·40	33·06	28 3 15	42 15 27·90	−5 53 11·17	50	24·90	14·50
40	24·86	33·42				20 55	23·64	14·56
45	23·33	33·77	29 2 0	42 9 17·01	−5 53 54·38	21 0	22·38	14·62
26 3 50	42 29 21·79	−5 50 34·13	5	15·68	54·50	5	21·12	14·67
			10	14·36	54·62	10	19·86	14·73
27 19 30	42 24 37·43	−5 51 36·07	15	13·04	54·74	15	18·60	14·79
27 19 35	42 24 35·94	−5 51 36·38	29 2 20	42 9 11·72	−5 53 54·86	30 21 20	42 4 17·74	−5 54 14·84

* The hours and minutes are in Greenwich sidereal time.

This table was calculated under the kind superintendence of Mr. Hind.

The 'Nautical Almanac (Hind's) Elements' were employed and corrected for perturbations by Venus, Earth, Mercury, Jupiter, and Saturn.

The heliocentric places were computed for intervals of twelve days, and the places for each 6th day were interpolated. From these the geocentric $\mathcal{R}$ and Declination were computed.

From these the intermediate $\mathcal{R}$s and Declinations were interpolated, having regard to differences of the 4th order.

TABLE II.—MERIDIAN OBSERVATIONS OF STARS COMPARED WITH JUNO, MADE BY DR. COPELAND WITH THE MERIDIAN CIRCLE OF THE DUNSINK OBSERVATORY.

Adopted name of star in Juno observations — No. in Weisse's Bessel	Date	Illuminated pivot	Apparent AR	Reduction to 1875·0	AR 1875·0	Apparent declination	Reduction to 1875·0	Declination 1875·0
			h. m. sec.		h. m. sec.	° ′ ″		° ′ ″
	1875, Dec. 3	W	2 47 3·41	−3·83	2 46 59·58	−5 45 22·64	−20·46	−5 45 43·10
χ	„ 14	W	3·45	−3·82	59·63	23·46	−19·18	42·64
	„ 28	W	3·55	−3·75	59·80	25·23	−17·72	42·95
W. B. II. 793*	1876, Jan. 1	E	3·61	−3·71	59·90	25·73	−17·24	42·97
	„ 15	E	3·34	−3·59	59·75	27·51	−16·12	43·63
					2 46 59·73			−5 45 43·06
	1875, Dec. 9	W	2 48 29·47	−3·83	2 48 25·64	−5 50 6·26	−19·72	−5 50 25·98
	„ 19	W	29·34	−3·80	25·54	7·04	−18·60	25·64
ν	„ 24	W	29·37	−3·78	25·59	6·97	−18·07	25·04
	1876, Jan. 9	E	29·19	−3·66	25·53	9·44	−16·55	25·99
W. B. II. 821†	„ 15	E	29·00	−3·60	25·40	9·12	−16·05	25·17
	„ 21	E	29·14	−3·53	25·61	10·07	−15·65	25·72
					2 48 25·57			−5 50 25·59
	1875, Dec. 14	W	2 50 32·26	−3·83	2 50 28·43	−5 51 8·91	−19·10	−5 51 28·01
μ	„ 28	W	32·17	−3·76	28·41	10·97	−17·61	28·58
	1876, Jan. 1	E	32·23	−3·73	28·50	10·77	−17·11	27·88
W. B. II. 867‡	„ 28	E	31·91	−3·45	28·46	12·19	−15·16	27·35
					2 50 28·45			−5 51 27·95
	1875, Dec. 3	W	2 52 28·61	−3·85	2 52 24·76	−4 42 16·29	−20·56	−4 42 36·85
λ	„ 19	W	28·43	−3·83	24·60	18·86	−18·79	37·65
	„ 24	W	28·55	−3·81	24·74	17·09	−18·27	35·36
W. B. II. 897§	1876, Jan. 9	E	28·08	−3·69	(24·39)	17·67	−16·78	(34·45)
	„ 21	E	28·24	−3·56	24·68	21·50	−15·88	37·38
					2 52 24·695			−4 42 36·81
	1875, Dec. 9	W	2 53 55·07	−3·86	2 53 51·21	−4 9 59·14	−19·97	−4 10 19·11
κ	„ 28	W	54·99	−3·79	51·20	10 0·60	−17·97	18·57
	1876, Jan. 1	E	55·09	−3·76	51·33	0·16	−17·52	17·68
W. B. II. 931§	„ 15	E	54·90	−3·64	51·26	2·31	−16·44	18·75
	„ 28	E	54·67	−3·48	51·19	2·52	−15·60	18·12
					2 53 51·24			−4 10 18·45
	1875, Dec. 3	W	2 57 57·45	−3·86	2 57 53·59	−5 43 40·02	−20·28	−5 44 0·30
ι	„ 14	W	57·59	−3·86	53·73	43·38	−18·95	2·33
	„ 24	W	57·39	−3·82	53·57	43·10	−17·86	0·96
W. B. II. 1002¶	1876, Jan. 1	E	57·46	−3·76	53·70	43·58	−16·95	0·53
	„ 21	E	57·22	−3·56	53·66	45·26	−15·36	0·62
					2 57 53·65			−5 44 0·95

* Deep yellow. † Yellow. ‡ Orange. § Bluish white.
¶ Very deep yellow.

TABLE II.—*continued.*

Adopted name of star in Juno observations — No. in Weisse's Bessel	Date	Illuminated pivot	Apparent AR	Reduction to 1875·0	AR 1875·0	Apparent declination	Reduction to 1875·0	Declination 1875·0
			h. m. sec.		h. m. sec.	° ′ ″		° ′ ″
	1875, Dec. 9	W	2 58 0·88	−3·87	2 57 57·01	−4 48 38·54	−19·75	−4 48 58·29
θ	„ 19	W	1·10	−3·85	57·25	39·74	−18·63	58·37
	„ 28	W	1·03	−3·80	57·23	39·54	−17·69	57·23
W. B. II. 1003*	1876, Jan. 15	E	0·89	−3·65	57·24	42·03	−16·09	58·12
	„ 28	E	0·73	−3·50	57·23	44·20	−15·24	59·44
					2 57 57·19			−4 48 58·29
	1875, Dec. 3	W	3 1 10·79	−3·86	3 1 6·93	−5 51 45·01	−20·20	−5 52 5·21
ζ	„ 14	W	10·83	−3·86	6·97	48·60	−18·86	7·46
	„ 19	W	10·66	−3·85	6·81	48·20	−18·28	6·48
W. B. II. 1068†	„ 24	W	10·87	−3·83	7·04	47·49	−17·74	5·23
	1876, Jan. 1	E	10·83	−3·77	7·06	48·13	−16·81	4·94
	„ 15	E	10·62	−3·66	6·96	50·09	−15·64	5·73
					3 1 6·96			−5 52 5·84
	1875, Dec. 3	W	3 5 7·22	−3·88	3 5 3·34	−4 16 47·75	−20·37	−4 17 8·12
z	„ 14	W	7·32	−3·89	3·43	50·42	−19·10	9·52
	„ 19	W	7·50	−3·88	3·62	50·03	−18·56	8·59
W. B. III. 50‡	„ 24	W	7·23	−3·86	3·37	49·49	−18·02	7·59
	1876, Jan. 15	E	7·05	−3·69	3·36	51·86	−16·01	7·87
	„ 21	E	7·07	−3·62	3·45	52·26	−15·58	7·84
					3 5 3·40			−4 17 8·24

* Yellow. † Yellow. ‡ Very deep yellow.

The probable error of an observation whose weight is 1 is for AR ±0$^{sec.}$·049, and for Declination ± 0″·44.

The observations are differential.

The following table exhibits the fundamental stars employed for clock error and equatorial point, with the order of observation :—

1875					1876				
December 3	December 9	December 14	December 19	December 24	January 1	January 9	January 15	January 21	January 28
Polaris	γ^2 Ceti	γ^2 Ceti	γ^2 Ceti	α Arietis	12 Ceti	ϵ Piscium	12 Ceti	67 Ceti	μ
β Arietis	ν	χ	ν	o Ceti	ϵ Piscium	α Arietis	ϵ Piscium	ξ^2 Ceti	κ
o Ceti	κ	μ	λ	ξ^2 Ceti	γ^2 Ceti	67 Ceti	α Arietis	ν	θ
ξ^2 Ceti	θ	ι	θ	γ^2 Ceti	χ	ξ^2 Ceti	ξ^2 Ceti	λ	δ Arietis
γ^2 Ceti	α Persei	ζ	ζ	ν	μ	ν	γ^2 Ceti	ι	α Persei
χ	η Tauri	z	z	λ	κ	λ	χ	β Persei	ϵ Eridani
λ	γ^1 Eridani	α Persei	α Persei	ι	ι	δ Arietis	ν	z	o^1 Eridani
ι	ϵ Tauri	ϵ Eridani	η Tauri	ζ	ζ	α Persei	κ	α Persei	β Orionis
ζ	α Tauri	η Tauri		z	δ Arietis		θ	o^1 Eridani	μ Geminorum
z		o^1 Eridani		α Persei	α Persei		ζ	α Orionis	
α Persei		ϵ Tauri		η Tauri	α Tauri		z	ν Orionis	
η Tauri		β Orionis		o^1 Eridani	β Orionis		α Persei	μ Geminorum	
γ^1 Eridani				ϵ Tauri	α Orionis		γ^1 Eridani		
				α Tauri	ν Orionis		o^1 Eridani		

The right ascensions of the Greenwich Catalogue for 1864, the declinations of the catalogue of 509 stars of the Astronomische Gesellschaft, have been adopted for the fundamental stars.

The same four microscopes have been used throughout the observations, and the errors of their screws have been determined by Dr. Copeland, and the proper corrections for these applied in the reductions.

The periodic errors of the circle used in the first position of the instrument were determined by Dr. Brunnow, and the corresponding corrections have been applied.

The errors of the other circle (E) have not yet been investigated, but it is probable that, like those of the first circle, they are exceedingly small, since no systematic difference appears in the results from the two circles; indeed, since the observations are differential, periodic error is nearly eliminated, and Dr. Brunnow has shown that the probable accidental errors of division are less than the probable error of a single reading.

The places of the stars for 1874·0, and the reduction constants by which the apparent places have been computed, are—

Juno star	AR 1874·0	1875·0 Ann. prec.	Dec. 1874·0	1875·0 Ann. prec.
	h. m. sec.		° ′ ″	″
χ	2 46 56·747	+2·983	−5 45 58·02	+14·96
ν	2 48 22·589	2·981	5 50 40·47	14·88
μ	2 50 25·471	2·979	5 51 42·71	14·76
λ	2 52 21·698	2·997	4 42 51·45	14·64
κ	2 53 48·235	3·005	4 10 33·01	14·56
ι	2 57 50·672	2·978	5 44 15·26	14·31
θ	2 57 54·197	2·993	4 49 12·60	14·31
ζ	3 1 3·985	3·975	5 52 19·95	14·11
z	3 5 0·400	+3·000	−4 17 22·10	+13·86

LOG. CONSTANTS FOR 1875·0.

Juno star	a	b	c	d	a_1	b_1	c_1	d_1
χ	+8·69889	+8·64950	+0·47458	−7·70060	+9·69770	−8·87449	+1·17498	−9·82339
ν	·69651	·65257	·47430	·70408	·69885	·87791	·17254	·82641
μ	·69299	·65685	·47413	·70184	·69960	·87566	·16901	·83066
λ	·68878	·66000	·47669	·60321	·68888	·77783	·16560	·83462
κ	·68588	·66258	·47787	·54770	·68374	·72264	·16302	·83752
ι	·67953	·67155	·47397	·67911	·70044	·85302	·15564	·84546
θ	·67878	·67102	·47617	·60285	·69124	·77740	·15553	·84557
ζ	·67355	·67778	·47345	·68318	·70265	·85699	·14956	·85159
z	+8·66482	+8·68399	+0·47711	−7·53830	+9·68722	−8·71317	+1·14189	−9·85886

TABLE III.—CORRECTIONS TO BE APPLIED TO STANDARD SIDEREAL CHRONOMETER (ELECTRIC CONTACT), DERIVED FROM TRANSIT OBSERVATIONS IN THE MERIDIAN MADE BY DR. COPELAND AT BELMONT WITH THE REVERSING TRANSIT INSTRUMENT.

1874	d.	h.		h.	m.	sec.		sec.
November	11	0·0	sidereal time	Correction −	0	1 23·80	Rate	+ 0·35
„	12	3·0	„	„		1 23·40		+ 0·37
„	13	0·1	„	„		1 23·06		+ 0·49
„	15	1·6	„	„		1 22·02		+ 0·58
„	16	23·7	„	„		1 21·49		+ 0·68
„	17	23·2	„	„		1 20·82		+ 0·28
„	18	23·5	„	„		1 20·54		+ 0·54
„	19	1·3	„	„		1 19·95		+ 0·60
„	20	5·9	„	„		1 19·25		+ 0·83
„	22	3·5	„	„		1 17·56		+ 0·85
„	23	5·1	„	„		1 16·67		+ 0·85
„	24	5·8	„	„		1 15·80		+ 0·93
„	25	6·6	„	„		1 14·94		+ 0·81
„	26	7·7	„	„		1 14·10		+ 0·76
„	29	9·2	„	„		1 11·77		+ 0·78
December	2	4·3	„	„		1 9·59		+ 0·50
„	3	3·3	„	„		1 9·10		+ 0·42
„	4	1·6	„	„		1 8·71		+ 0·92
„	5	5·8	„	„		1 7·63		+ 0·73
„	6	4·7	„	„		1 6·94		+ 0·80
„	7	5·7	„	„		1 6·11		+ 0·78
„	8	3·2	„	„		1 5·41		+ 0·95
„	9	0·6	„	„		1 4·56		+ 1·07
„	10	4·7	„	„		1 3·31		+ 1·21
„	11	3·6	„	„		1 2·15		+ 1·03
„	16	3·4	„	„		0 57·00		+ 0·99
„	17	1·8	„	„		0 56·07		+ 0·99
„	19	3·0	„	„		0 54·03		
„	21	2·3	„	„		0 52·28		
„	21	6·9	„	„		0 51·98		+ 0·92
„	22	3·4	„	„		0 51·09		+ 1·22
„	23	2·4	„	„		0 50·04		+ 1·10

The standard sidereal chronometer called 'Electric Contact' (or E.C.) was provided with light springs, which, by a toothed wheel on the arbor of the seconds wheel, were separated, and broke contact every second (the 60th second excepted). This caused a relay to make contact once a second in a more powerful circuit, by which the chronograph was worked.

The blows of the pricker of the chronograph were sensibly in coincidence with the beats of the chronometer, so that the comparisons of the observing sidereal chronometer were made indifferently with the chronometer in the usual way, or with the blows of the chronograph—the difference (not exceeding ·02 or ·03 second) being entirely insensible in its effect on the Juno observations.

The results given above for correction of the chronometer E.C. result from the first computation; the results of the final computation may in some instances differ from them a few hundredth-parts of a second, because the star places have been revised and in some cases altered. In no case will the alterations produce 0ˢ·1 change in time, which corresponds *at a*

maximum with a change of o″·001 in the place of Juno. For details of time determinations see Vol. III.

TABLE IV.—COMPARISONS BETWEEN CHRONOMETERS GENERALLY USED IN THE HELIOMETER OBSERVATIONS [SIDEREAL CHRONOMETER (43)] AND THE STANDARD CHRONOMETER (E.C.)

1874	Time by E.C. hrs.	min.	sec.		Time by 43 hrs.	min.	sec.
November 12	0	29	0·0	=	0	27	12·5
„ 13	1	41	0·0		1	39	11·0
„ 17	0	0	0·0		23	58	3·5
„ 18	13	49	0·0		13	47	0·5
„ 20	22	50	3·5		22	48	0·0
„ 24	23	0	13·0		22	58	0·0
„ 25	7	36	0·0		7	33	42·8
„ 26	23	26	0·0		23	23	41·5
„ 27	22	56	0·0		22	53	38·8
„ 28 *	23	32	0·0		23	29	13·6
„ 29	14	53	0·0		14	51	10·6
„ 30	1	25	0·0		1	22	9·6
December 8	10	39	0·0		10	35	52·8
Chronometer set forward three minutes.							
	hrs.	min.	sec.		hrs.	min.	sec.
December 8	15	48	30·0		15	48	22·2
„ 10	6	33	0·0		6	32	47·3
„ 13	0	2	0·0		0	1	38·5
„ 21	7	14	0·0		7	13	15·0
„ 24	11	12	0·0		11	11	5·0

* The chronometer was allowed to run down, was re-wound and re-set.

These comparisons, made by estimating $\frac{1}{10}$th seconds, are sufficiently accurate, seeing that an error of one second will not produce an error of o″·01 in any of the tabular distances of Juno.

The comparisons here given on December 8 are only rough check comparisons; the accurate comparisons on the day of transit of Venus will be found in Vol. IV. After November 30 only a very rough approximation of the chronometer correction is required for the computation of refractions; the few comparisons given are therefore amply sufficient.

TABLE V.—CORRECTIONS TO BE APPLIED TO CHRONOMETER (43) FOR ITS ERROR ON LOCAL SIDEREAL TIME AT BELMONT IN THE HELIOMETER MEASURES.

1874	d.	hrs.			min.	sec.		sec.
November	10	0·0	sidereal time	Correction +	0	20·0	Adopted hourly rate +	0·08
„	11	0·0	„	„	0	22·0	„	·09
„	12	0·0	„	„	0	24·1	„	·10
„	13	0·0	„	„	0	26·4	„	·10
„	14	0·0	„	„	0	28·9	„	·11
„	15	0·0	„	„	0	31·6	„	·11
„	16	0·0	„	„	0	34·3	„	·11
„	17	0·0	„	„	0	35·7	„	·11
„	18	0·0	„	„	0	38·6	„	·11
„	19	0·0	„	„	0	41·4	„	·12
„	20	0·0	„	„	0	44·2	„	·12
„	21	0·0	„	„	0	47·4	„	·13
„	22	0·0	„	„	0	50·6	„	·14
„	23	0·0	„	„	0	53·8	„	·14

TABLE V.—CORRECTIONS TO BE APPLIED, &c.—*continued.*

1874	d.	hrs.			min.	sec.		sec.
November	24	0·0	sidereal time	Correction	+0	57·0	Adopted hourly rate	+ 0·15
„	25	0·0	„	„	1	1·0	„	·15
„	26	0·0	„	„	1	4·2	„	·15
„	27	0·0	„	„	1	7·8	„	·15

Chronometer was allowed to run down, was re-wound and re-set.

	d.	hrs.			min.	sec.
November	28	0·0	sidereal time	Correction	+ 1	33·0
„	29	0·0	„	„	1	36·0*
„	30	0·0	„	„	1	39·0

Approximate Corrections for Computing Refractions.

	d.	hrs.			min.	sec.
December	2	20	sidereal time	Correction	+ 1	47
„	6	12	„	„	1	58
„	7	12	„	„	2	0
„	8	12	„	„	+2	2†
„	10	6·5	„	„	−0	50·5
„	13	0	„	„	0	39·8
„	14	21	„	„	0	36
„	21	7·2	„	„	−0	7·0
„	24	11·2	„	„	+0	6·5

Chronometer (31).

A mean time chronometer.

December 23, 6 h. 6 m. [by (31)]. Fast 2 h. 0 m. 21 sec. on sidereal time (losing 10 seconds per hour on sidereal time).

* In the original comparison this comes out +0 m. 36·0 sec.; a mistake of 1 minute is assumed.

† December 8. The chronometer was set forward 3 minutes.

Table VI.

TABULAR DISTANCES, POSITION ANGLES, AND FACTORS FOR JUNO AND COMPARISON STARS.

No. of group — Date — Star of comparison	Rotation number	Time by chronometer	Local sidereal time	Greenwich sidereal time	Right ascension of star	Declination of star	Geocentric right ascension of planet	Geocentric declination of planet
		h. m. sec.	h. m. sec.	h. m. sec.	° ′ ″	° ′ ″	° ′ ″	° ′ ″
	1	23 14 50	23 15 10	19 24 20	46 15 57·26	−4 17 1·27	45 4 44·64	−4 30 9·23
	2	23 14 50	23 15 10	19 24 20	,,	,,	44·64	9·23
	3	23 24 28	23 24 48	19 33 58	,,	,,	40·39	12·45
I.	4	23 24 28	23 24 48	19 33 58	,,	,,	40·39	12·45
Nov. 10, 1874, evening	4 bis	23 30 55	23 31 15	19 40 25	,,	,,	37·56	14·58
z	5	23 30 55	23 31 15	19 40 25	,,	,,	37·56	14·58
	6	23 41 7	23 41 27	19 50 37	,,	,,	33·07	17·98
	7	23 41 7	23 41 27	19 50 37	,,	,,	33·07	17·98
	8	0 4 58	0 5 18	20 14 28	43 27 54·77	−4 10 12·07	45 4 22·53	−4 30 25·93
	9	0 4 58	0 5 18	20 14 28	,,	,,	22·53	25·93
II.	10	0 11 43	0 12 3	20 21 13	,,	,,	19·57	28·17
Nov. 10, 1874, evening	11	0 11 43	0 12 3	20 21 13	,,	,,	19·57	28·17
κ	12	0 7 35	0 7 55	20 17 5	,,	,,	21·39	26·79
	13	0 17 33	0 17 53	20 27 3	,,	,,	17·00	30·11
	14	0 17 33	0 17 53	20 27 3	,,	,,	17·00	30·11
	15	0 27 43	0 28 3	20 37 13	43 27 54·77	−4 10 12·07	45 4 12·52	−4 30 33·50
	16	0 27 43	0 28 3	20 37 13	,,	,,	12·52	33·50
	17	0 32 1	0 32 21	20 41 31	,,	,,	10·63	34·91
III.	18	0 32 1	0 32 21	20 41 31	,,	,,	10·63	34·91
Nov. 10, 1874, evening	18 bis	0 35 27	0 35 47	20 44 57	,,	,,	9·11	36·06
κ	19	0 35 27	0 35 47	20 44 57	,,	,,	9·11	36·06
	20	0 40 40	0 41 0	20 50 10	,,	,,	6·81	37·79
	21	0 40 40	0 41 0	20 50 10	,,	,,	6·81	37·79
	22	1 2 23	1 2 43	21 11 53	46 15 57·27	−4 17 1·28	45 3 57·23	−4 30 45·00
IV.	23	1 2 23	1 2 43	21 11 53	,,	,,	57·23	45·00
Nov. 10, 1874, evening	24	1 6 29	1 6 49	21 15 59	,,	,,	55·43	46·37
z	25	1 6 29	1 6 49	21 15 59	,,	,,	55·43	46·37
	26	6 52 50	6 53 15·5	3 2 25·5	46 15 57·30	−4 17 1·30	45 1 22·80	−4 32 40·76
	27	6 55 20	6 55 40·5	3 4 50·5	,,	,,	21·73	41·55
	28	7 1 23	7 1 43·5	3 10 53·5	,,	,,	19·07	43·53
V.	29	6 59 30	6 59 50·5	3 9 0·5	,,	,,	19·90	42·91
Nov. 10, 1874, morning	29 bis	7 4 25	7 4 45·5	3 13 55·5	,,	,,	17·74	44·53
z	30	7 6 49	7 7 9·5	3 16 19·5	,,	,,	16·68	45·32
	31	7 9 50	7 10 10·5	3 19 20·5	,,	,,	15·35	46·31
	32	7 10 30	7 10 50·5	3 20 0·5	,,	,,	15·06	46·53
	33	7 19 17	7 19 37·5	3 28 47·5	43 27 54·80	−4 10 12·09	45 1 11·19	−4 32 49·41
	34	7 20 41	7 21 1·5	3 30 11·5	,,	,,	10·57	49·87
VI.	35	7 27 15	7 27 35·5	3 36 45·5	,,	,,	7·69	52·02
Nov. 10, 1874, morning	36	7 31 15	7 31 35·5	3 40 45·5	,,	,,	5·93	53·34
κ	37	7 32 27	7 32 47·5	3 41 57·5	,,	,,	5·40	53·73
	38	7 36 20	7 36 40·5	3 45 50·5	,,	,,	3·69	55·00
	39	7 41 10	7 41 30·5	3 50 40·5	,,	,,	1·56	56·59
VII.								
Nov. 10, 1874, morning	40	7 44 5	7 44 25·5	3 53 35·5	43 27 54·80	−4 10 12·09	45 0 58·28	−4 32 57·55
κ	41	7 47 10	7 47 30·5	3 56 40·5	,,	,,	58·91	58·55

Parallax in Æ	Parallax in Dec.	Distances				Position Angles				Rotation number
		Tabular distance	Par. factor in distance	Factor for change of Æ	Factor for change of Dec.	Tabular position angle	Par. factor in pos. angle	Factor for change of Æ	Factor for change of Dec.	
		″	*f‴*	*f′*	*f″*	° ′	*f‴*	*f′*	*f″*	
+6″72	+2″56	...	...	...	...	259 32·30	+0·010	−0·144	+0·784	1
+6·72	+2·56	4325·27	−0·0705	−0·9805	−0·1816	...	...	...	...	2
+6·52	+2·54	4330·22	−0·0685	−0·9803	−0·1821	...	...	...	...	3
+6·52	+2·54	...	...	...	...	259 30·41	+0·011	−0·145	+0·783	4
+6·39	+2·53	...	...	...	...	259 29·17	+0·011	−0·145	+0·782	4 bis
+6·39	+2·53	4333·51	−0·0672	−0·9803	−0·1825	...	...	...	...	5
+6·16	+2·50	4338·76	−0·0650	−0·9802	−0·1831	...	...	...	...	6
+6·16	+2·50	...	...	...	...	259 27·18	+0·010	−0·145	+0·781	7
+5·59	+2·45	...	...	...	...	101 50·57	−0·021	−0·120	−0·572	8
+5·59	+2·45	5902·39	+0·0496	+0·9759	−0·2052	...	...	...	...	9
+5·41	+2·44	5899·79	+0·0478	+0·9758	−0·2057	...	...	...	...	10
+5·41	+2·44	...	...	...	...	101 52·23	−0·020	−0·120	−0·572	11
+5·56	+2·45	5901·43	+0·0493	+0·9759	−0·2054	...	...	...	...	12
+5·26	+2·43	5897·53	+0·0463	+0·9757	−0·2061	...	...	...	...	13
+5·26	+2·43	...	...	...	...	101 53·66	−0·020	−0·120	−0·572	14
+5·00	+2·42	...	...	...	...	101 56·17	−0·020	−0·119	−0·572	15
+5·00	+2·42	5893·61	+0·0438	+0·9756	−0·2068	...	...	...	...	16
+4·86	+2·41	5891·92	+0·0424	+0·9755	−0·2071	...	...	...	...	17
+4·86	+2·41	...	...	...	...	101 57·23	−0·020	−0·121	−0·572	18
+4·76	+2·40	...	...	...	...	101 58·07	−0·020	−0·121	−0·572	18 bis
+4·76	+2·40	5890·58	+0·0414	+0·9755	−0·2074	...	...	...	...	19
+4·60	+2·39	5888·54	+0·0398	+0·9754	−0·2077	...	...	...	...	20
+4·60	+2·39	...	...	...	...	101 59·38	−0·019	−0·121	−0·573	21
+3·97	+2·36	...	...	...	...	259 11·68	+0·012	−0·147	+0·773	22
+3·97	+2·36	4381·04	−0·0433	−0·9794	−0·1875	...	...	...	...	23
+3·84	+2·35	4383·19	−0·0420	−0·9793	−0·1877	...	...	...	...	24
+3·84	+2·35	...	...	...	...	259 10·90	+0·013	−0·147	+0·773	25
−6·87	+2·58	...	...	...	...	258 9·48	+0·030	−0·155	+0·739	26
−6·91	+2·58	4566·49	+0·0621	−0·9758	−0·2053	...	...	...	...	27
−7·02	+2·60	4569·59	+0·0632	−0·9757	−0·2056	...	...	...	...	28
−6·98	+2·60	...	...	...	...	258 8·38	+0·030	−0·155	+0·739	29
−7·07	+2·60	...	...	...	...	258 7·53	+0·030	−0·155	+0·738	29 bis
−7·12	+2·61	4572·38	+0·0641	−0·9757	−0·2059	...	...	...	...	30
−7·17	+2·62	4573·93	+0·0645	−0·9756	−0·2060	...	...	...	...	31
−7·18	+2·62	...	...	...	...	258 6·51	+0·030	−0·155	+0·738	32
−7·33	+2·64	...	...	...	...	103 39·71	−0·005	−0·142	−0·584	33
−7·35	+2·64	5734·66	−0·0774	+0·9689	−0·2363	...	...	...	...	34
−7·42	+2·65	5732·31	−0·0782	+0·9688	−0·2368	...	...	...	...	35
−7·48	+2·66	...	...	...	...	103 42·76	−0·005	−0·142	−0·584	36
−7·51	+2·66	5730·40	−0·0790	+0·9687	−0·2372	...	...	...	...	37
−7·54	+2·68	5729·02	−0·0794	+0·9686	−0·2374	...	...	...	...	38
−7·60	+2·69	...	...	...	...	103 45·27	−0·005	−0·143	−0·585	39
−7·64	+2·70	...	...	...	...	103 46·02	−0·005	−0·143	−0·585	40
−7·68	+2·71	...	...	...	...	103 46·79	−0·005	−0·143	−0·585	41

No. of group — Date — Star of comparison	Rotation number	Time by chronometer	Local sidereal time	Greenwich sidereal time	Right ascension of star	Declination of star	Geocentric right ascension of planet	Geocentric declination of planet
		h. m. sec.	h. m. sec.	h. m. sec.	° ′ ″	° ′ ″	° ′ ″	° ′ ″
VIII. Nov. 10, 1874, morning *z*	42	7 51 55	7 52 15·5	4 1 25·5	46 15 57·30	−4 17 1·30	45 0 56·83	−4 33 0·12
	43	7 57 10	7 57 30·5	4 6 40·5	,,	,,	54·51	1·83
IX. Nov. 11, 1874, evening *z*	44	22 22 48	22 23 10	18 32 20	46 15 57·39	−4 17 1·37	44 54 33·88	−4 37 41·74
	45	22 25 52	22 26 14	18 35 24	,,	,,	32·52	42·72
	46	22 34 37·5	22 34 59·5	18 44 9·5	,,	,,	28·70	45·52
	47	22 31 27·5	22 31 49·5	18 40 59·5	,,	,,	30·06	44·51
	48	22 38 18	22 38 40	18 47 50	,,	,,	27·07	46·69
	49	22 42 25·5	22 42 47·5	18 51 57·5	,,	,,	25·24	48·01
	50	22 45 23	22 45 45	18 54 55	,,	,,	23·95	48·95
X. Nov. 12, 1874, evening *θ*	51	22 24 52	22 25 16	18 34 26	44 29 24·41	−4 48 51·92	44 44 2·49	−4 45 10·87
	52	22 26 52	22 27 16	18 36 26	,,	,,	1·61	11·47
	53	22 30 16	22 30 40	18 39 50	,,	,,	44 0·14	12·50
	54	22 33 2	22 33 26	18 42 36	,,	,,	43 58·93	13·34
	54 bis	22 41 2	22 41 26	18 50 36	,,	,,	55·42	15·77
	55	22 43 43	22 44 7	18 53 17	,,	,,	54·27	16·58
	56	22 48 18	22 48 42	18 57 52	,,	,,	52·27	17·98
	57	22 50 49	22 51 13	19 0 23	,,	,,	51·16	18·75
XI. Nov. 12, 1874, evening *θ*	58	22 57 24	22 57 48	19 6 58	44 29 24·41	−4 48 51·92	44 43 48·28	−4 45 20·75
	59	22 58 29	22 58 53	19 8 3	,,	,,	47·83	21·07
	60	23 2 34	23 2 58	19 12 8	,,	,,	46·02	22·32
	61	23 5 25	23 5 49	19 14 59	,,	,,	44·79	23·18
	61 bis	23 6 35	23 6 59	19 16 9	,,	,,	44·27	23·53
	62	23 10 10	23 10 34	19 19 44	,,	,,	42·74	24·62
	63	23 13 25	23 13 49	19 22 59	,,	,,	41·30	25·59
	64	23 17 44	23 18 8	19 27 18	,,	,,	39·41	26·92
XII. Nov. 12, 1874, evening *θ*	65	23 27 14	23 27 38	19 36 48	44 29 24·42	−4 48 51·93	44 43 35·25	−4 45 29·80
	66	23 29 43	23 30 7	19 39 17	,,	,,	34·20	30·55
	67	23 34 8	23 34 32	19 43 42	,,	,,	32·28	31·89
	68	23 38 33	23 38 57	19 48 7	,,	,,	30·34	33·22
	68 bis	23 40 37	23 41 1	19 50 21	,,	,,	29·37	33·91
	69	23 42 15	23 42 39	19 51 49	,,	,,	28·71	34·36
	70	23 46 42	23 47 6	19 56 16	,,	,,	26·78	35·70
	71	23 49 27	23 49 51	19 59 1	,,	,,	25·60	36·53
XIII. Nov. 12, 1874, evening *θ*	72	23 58 15	23 58 39	20 7 49	44 29 24·42	−4 48 51·93	44 43 21·75	−4 45 39·19
	73	23 59 42	0 0 6	20 9 16	,,	,,	21·12	39·64
	74	0 4 29	0 4 53	20 14 3	,,	,,	19·03	41·08
	75	0 9 20	0 9 44	20 18 54	,,	,,	16·92	42·56
XIV. Nov. 12, 1874, morning *θ*	76	5 14 59	5 15 23·5	1 24 33·5	44 29 24·44	−4 48 51·94	44 41 3·69	−4 47 14·61
	77	5 16 36	5 17 0·5	1 26 10·5	,,	,,	2·98	15·10
	78	5 21 39	5 22 3·5	1 31 13·5	,,	,,	41 0·78	16·61
	79	5 24 41	5 25 5·5	1 34 15·5	,,	,,	40 59·49	17·51
	79 bis	5 28 45	5 29 9·5	1 38 19·5	,,	,,	57·71	18·74
	80	5 30 51	5 31 15·5	1 40 25·5	,,	,,	56·78	19·37
	81	5 33 35	5 33 59·5	1 43 9·5	,,	,,	55·61	20·18
	82	5 41 7	5 41 31·5	1 50 41·5	,,	,,	52·32	22·44

Parallax in AR	Parallax in Dec.	Distances				Position Angles				Rotation number
		Tabular distance	Par. factor in distance	Factor for change of AR	Factor for change of Dec.	Tabular position angle	Par. factor in pos. angle	Factor for change of AR	Factor for change of Dec.	
"	"	"	f'''	f'	f''	° ′	f'''	f'	f''	
−7·71	+2·73	...	...	...	...	257 59·52	+0·032	−0·156	+0·734	42
−7·78	+2·74	...	...	...	..	257 58·65	+0·032	−0·156	+0·733	43
+7·54	+2·67	...	...	...	...	255 42·98	+0·005	−0·169	+0·666	44
+7·50	+2·66	5017·91	−0·0790	−0·9661	−0·2468	...	...	...	...	45
+7·39	+2·64	5022·40	−0·0779	−0·9660	−0·2472	...	...	...	...	46
+7·43	+2·65	...	...	...	...	255 41·79	+0·005	−0·169	+0·666	47
+7·33	+2·63	5024·32	−0·0773	−0·9660	−0·2473	...	...	...	...	48
+7·27	+2·62	5026·48	−0·0767	−0·9660	−0·2475	...	...	...	...	49
+7·22	+2·62	...	...	...	...	255 39·89	+0·005	−0·169	+0·664	50
+7·50	+2·66	...	...	...	...	75 46·52	−0·028	+0·928	−3·674	51
+7·47	+2·65	909·38	+0·0787	+0·9661	+0·2453	...	...	...	...	52
+7·42	+2·64	907·66	+0·0782	+0·9662	+0·2447	...	...	...	...	53
+7·38	+2·63	...	...	...	...	75 52·30	−0·029	+0·926	−3·692	54
+7·26	+2·62	...	...	...	...	75 57·95	−0·030	+0·924	−3·710	54 bis
+7·23	+2·61	900·80	+0·0762	+0·9669	+0·2420	...	...	...	...	55
+7·16	+2·60	898·46	+0·0755	+0·9671	+0·2410	...	...	...	...	56
+7·13	+2·59	...	...	...	...	76 5·07	−0·031	+0·922	−3·732	57
+7·00	+2·59	...	...	...	...	76 9·76	−0·033	+0·920	−3·748	58
+6·98	+2·59	893·24	+0·0737	+0·9677	+0·2389	...	...	...	...	59
+6·91	+2·58	891·12	+0·0730	+0·9679	+0·2381	...	...	...	...	60
+6·85	+2·56	...	...	...	...	76 15·64	−0·034	+0·918	−3·767	61
+6·83	+2·55	...	...	...	...	76 16·50	−0·033	+0·918	−3·769	61 bis
+6·76	+2·54	887·25	+0·0714	+0·9682	+0·2365	...	...	...	...	62
+6·69	+2·53	885·55	+0·0708	+0·9684	+0·2359	...	...	...	...	63
+6·62	+2·52	...	...	...	...	76 24·76	−0·035	+0·914	−3·796	64
+6·42	+2·50	...	...	...	...	76 31·75	−0·037	+0·912	−3·819	65
+6·37	+2·49	877·18	+0·0675	+0·9692	+0·2324	...	...	...	...	66
+6·27	+2·48	874·91	+0·0665	+0·9694	+0·2315	...	...	...	...	67
+6·17	+2·47	...	...	...	...	76 40·25	−0·039	+0·908	−3·847	68
+6·12	+2·46	...	...	...	...	76 42·01	−0·039	+0·908	−3·853	68 bis
+6·09	+2·46	870·70	+0·0648	+0·9699	+0·2297	...	...	...	...	69
+5·98	+2·45	868·41	+0·0636	+0·9701	+0·2288	...	...	...	...	70
+5·92	+2·45	...	...	...	...	76 48·55	−0·041	+0·905	−3·874	71
+5·71	+2·43	...	...	...	...	76 55·27	−0·043	+0·902	−3·896	72
+5·67	+2·43	861·72	+0·0605	+0·9707	+0·2260	...	...	...	...	73
+5·55	+2·42	859·25	+0·0593	+0·9710	+0·2249	...	...	...	...	74
+5·42	+2·41	...	...	...	...	77 3·89	−0·046	+0·896	−3·925	75
−4·52	+2·35	...	...	...	...	81 48·39	−0·146	+0·700	−4·881	76
−4·57	+2·35	698·61	−0·0418	+0·9864	+0·1420	...	...	...	...	77
−4·72	+2·36	696·08	−0·0433	+0·9866	+0·1403	...	...	...	...	78
−4·81	+2·36	...	...	...	...	81 59·40	−0·149	+0·690	−4·918	79
−4·92	+2·37	...	...	...	...	82 4·09	−0·151	+0·685	−4·934	79 bis
−4·97	+2·37	691·51	−0·0458	+0·9871	+0·1373	...	...	...	...	80
−5·04	+2·38	690·17	−0·0466	+0·9872	+0·1364	...	...	...	...	81
−5·25	+2·39	...	...	...	...	82 18·40	−0·154	+0·671	−4·981	82

No. of group — Date — Star of comparison	Rotation number	Time by chronometer	Local sidereal time	Greenwich sidereal time	Right ascension of star	Declination of star	Geocentric right ascension of planet	Geocentric declination of planet
		h. m. sec.	h. m. sec.	h. m. sec.	° ′ ″	° ′ ″	° ′ ″	° ′ ″
	83	5 50 45	5 51 9·5	2 0 19·5	44 29 24·44	−4 48 51·94	44 40 48·12	−4 47 25·33
	84	5 53 8	5 53 32·5	2 2 42·5	,,	,,	47·10	26·03
XV.	85	5 56 56	5 57 20·5	2 6 30·5	,,	,,	45·43	27·17
Nov. 12, 1874, morning	86	6 3 15	6 3 39·5	2 12 49·5	,,	,,	42·70	29·06
θ	86 bis	6 4 53	6 5 17·5	2 14 27·5	,,	,,	41·97	29·56
	87	6 9 5	6 9 29·5	2 18 39·5	,,	,,	40·15	30·80
	88	6 13 18	6 13 42·5	2 22 52·5	,,	,,	38·33	32·06
	89	6 17 56	6 18 20·5	2 27 30·5	,,	,,	36·29	33·45
	90	6 26 55	6 27 20	2 36 30	44 29 24·45	−4 48 51·95	44 40 32·37	−4 47 36·14
	91	6 28 20	6 28 45	2 37 55	,,	,,	31·76	36·55
XVI.	92	6 33 10	6 33 35	2 42 45	,,	,,	29·67	37·99
Nov. 12, 1874, morning	93	6 35 51	6 36 16	2 45 26	,,	,,	28·49	38·80
θ	94	6 37 48	6 38 13	2 47 23	,,	,,	27·64	39·39
	95	6 42 25	6 42 50	2 52 0	,,	,,	25·63	40·77
	96	6 45 0	6 45 25	2 54 35	,,	,,	24·51	41·54
	97	6 54 26	6 54 51	3 4 1	44 29 24·45	−4 48 51·95	44 40 20·41	−4 47 44·35
	98	6 55 41·5	6 56 6·5	3 5 16·5	,,	,,	19·85	44·72
XVII.	99	6 59 55	7 0 20	3 9 30	,,	,,	18·01	45·99
Nov. 12, 1874, morning	100	7 2 46	7 3 11	3 12 21	,,	,,	16·77	46·85
θ	100 bis	7 5 55	7 6 20	3 15 30	,,	,,	15·40	47·78
	101	7 7 9	7 7 34	3 16 44	,,	,,	14·86	48·15
	102	7 11 28	7 11 53	3 21 3	,,	,,	12·98	49·44
	103	7 14 47	7 15 12	3 24 22	,,	,,	11·54	50·42
	104	22 12 26	22 12 52	18 22 2	44 29 24·53	−4 48 52·02	44 33 41·99	−4 52 13·89
	105	22 15 15·5	22 15 41·5	18 24 51·5	,,	,,	40·79	14·69
XVIII.	106	22 19 53	22 20 19	18 29 29	,,	,,	38·77	16·04
Nov. 13, 1874, evening	107	22 22 50	22 23 16	18 32 26	,,	,,	37·50	16·89
θ	107 bis	22 24 6	22 24 32	18 33 42	,,	,,	36·94	17·25
	108	22 25 53·5	22 26 19·5	18 35 29·5	,,	,,	36·16	17·77
	109	22 28 45	22 29 11	18 38 21	,,	,,	34·94	18·59
	110	22 31 45	22 32 11	18 41 21	,,	,,	33·65	19·46
	111	22 41 58	22 42 24	18 51 34	44 29 24·53	−4 48 52·02	44 33 29·22	−4 52 22·41
	112	22 42 58	22 43 24	18 52 34	,,	,,	28·78	22·70
XIX.	113	22 45 30	22 45 56	18 55 6	,,	,,	27·68	23·43
Nov. 13, 1874, evening	114	22 48 20	22 48 46	18 57 56	,,	,,	26·46	24·24
θ	114 bis	22 49 16	22 49 42	18 58 52	,,	,,	26·06	24·51
	115	22 50 30	22 50 56	19 0 6	,,	,,	25·52	24·87
	116	22 52 40	22 53 6	19 2 16	,,	,,	24·59	25·50
	117	22 55 40·5	22 56 6·5	19 5 16·5	,,	,,	23·28	26·36

Parallax in AR	Parallax in Dec.	Distances				Position Angles				Rotation number
		Tabular distance	Par. factor in distance	Factor for change of AR	Factor for change of Dec.	Tabular position angle	Par. factor in pos. angle	Factor for change of	Factor for change of Dec.	
−5″.49	+2″.41	″	*f‴*	*f′*	*f″*	82° 29′.76	*f‴* −0.157	*f′* +0.659	*f″* −5.018	83
−5.57	+2.42	680.47	−0.0519	+0.9881	+0.1298	...	...	...	...	84
−5.67	+2.43	678.58	−0.0529	+0.9882	+0.1285	...	...	...	...	85
−5.83	+2.44	...	...	...	...	82 44.61	−0.161	+0.643	−5.067	86
−5.86	+2.44	...	...	...	...	82 46.65	−0.161	+0.641	−5.073	86 bis
−5.96	+2.45	672.61	−0.0559	+0.9888	+0.1243	...	...	...	...	87
−6.06	+2.46	670.56	−0.0569	+0.9889	+0.1228	...	...	...	...	88
−6.16	+2.47	...	...	...	...	83 2.50	−0.165	+0.623	−5.124	89
−6.36	+2.49	...	...	...	...	83 13.59	−0.167	+0.611	−5.161	90
−6.39	+2.49	663.19	−0.0603	+0.9896	+0.1174	...	...	...	...	91
−6.49	+2.50	660.85	−0.0613	+0.9898	+0.1157	...	...	..	...	92
−6.55	+2.51	...	...	...	...	83 24.76	−0.170	+0.598	−5.196	93
−6.59	+2.51	658.59	−0.0623	+0.9900	+0.1140	...	...	...	...	94
−6.68	+2.52	656.35	−0.0633	+0.9902	+0.1123	..	...	...	...	95
−6.74	+2.53	...	...	...	...	83 36.44	−0.172	+0.584	−5.234	96
−6.91	+2.55	...	...	...	...	83 48.59	−0.174	+0.570	−5.272	97
−6.94	+2.56	649.94	−0.0661	+0.9907	+0.1074	...	...	...	...	98
−7.01	+2.57	647.91	−0.0668	+0.9909	+0.1058	...	...	...	...	99
−7.05	+2.58	...	...	...	...	83 59.48	−0.176	+0.557	−5.307	100
−7.11	+2.59	...	...	...	...	84 3.56	−0.177	+0.552	−5.320	100 bis
−7.14	+2.59	644.44	−0.0681	+0.9912	+0.1030	...	...	...	...	101
−7.21	+2.60	642.37	−0.0689	+0.9914	+0.1014	...	...	...	...	102
−7.25	+2.61	...	...	...	...	84 15.33	−0.179	+0.537	−5.357	103
+7.62	+2.68	...	...	...	...	127 1.25	−0.700	−6.257	−8.327	104
+7.59	+2.67	330.33	+0.0440	+0.7931	−0.6055	...	...	...	...	105
+7.53	+2.66	329.52	+0.0431	+0.7887	−0.6111	...	...	...	...	106
+7.49	+2.66	...	...	...	...	127 55.41	−0.701	−6.422	−8.272	107
+7.47	+2.65	...	...	...	...	128 2.18	−0.700	−6.443	−8.265	107 bis
+7.46	+2.65	328.48	+0.0420	+0.7831	−0.6183	...	...	...	...	108
+7.42	+2.63	328.02	+0.0416	+0.7804	−0.6217	...	...	...	...	109
+7.38	+2.62	...	...	...	...	128 42.48	−0.700	−6.564	−8.220	110
+7.23	+2.60	...	...	...	...	129 37.04	−0.698	−6.727	−8.156	111
+7.21	+2.59	325.70	+0.0388	+0.7666	−0.6389	...	...	...	...	112
+7.17	+2.59	325.30	+0.0382	+0.7640	−0.6419	...	...	...	...	113
+7.13	+2.58	...	...	...	...	130 11.35	−0.696	−6.829	−8.113	114
+7.12	+2.58	...	...	...	...	130 16.32	−0.697	−6.844	−8.107	114 bis
+7.10	+2.58	324.54	+0.0372	+0.7590	−0.6479	...	...	...	...	115
+7.07	+2.57	324.22	+0.0368	+0.7568	−0.6505	...	...	...	...	116
+7.01	+2.56	...	...	...	...	130 51.24	−0.693	−6.946	−8.060	117

No. of group — Date — Star of comparison	Rotation number	Time by chronometer	Local sidereal time	Greenwich sidereal time	Right ascension of star	Declination of star	Geocentric right ascension of planet	Geocentric declination of planet
		h. m. sec.	h. m. sec.	h. m. sec.	° ′ ″	° ′ ″	° ′ ″	° ′ ″
	118	23 4 41	23 5 7	19 14 17	44 29 24·53	−4 48 52·02	44 33 19·40	−4 52 28·95
	119	23 6 15	23 6 41	19 15 51	„	„	18·73	29·41
XX.	120	23 9 7	23 9 33	19 18 43	„	„	17·47	30·22
Nov. 13, 1874, evening	121	23 11 17	23 11 43	19 20 53	„	„	16·54	30·86
θ	121 bis	23 13 0·5	23 13 26·5	19 22 36·5	„	„	15·79	31·34
	122	23 14 10·5	23 14 36·5	19 23 46·5	„	„	15·28	31·68
	123	23 18 43·5	23 19 9·5	19 28 19·5	„	„	13·32	32·99
	124	23 21 58·5	23 22 24·5	19 31 34·5	„	„	11·92	33·93
	125	23 27 40·5	23 38 6·5	19 47 16·5	44 29 24·53	−4 48 52·02	44 33 5·12	−4 52 38·46
	126	23 39 9	23 39 35	19 48 45	„	„	4·48	38·87
XXI.	127	23 42 13	23 42 39	19 51 49	„	„	3·15	39·76
Nov. 13, 1874, evening	128	23 46 10	23 46 36	19 55 46	„	„	1·44	40·89
θ	128 bis	23 47 13	23 47 39	19 56 49	„	„	0·99	41·20
	129	23 48 28	23 48 54	19 58 4	„	„	33 0·45	41·55
	130	23 51 18·5	23 51 44·5	20 0 54·5	„	„	32 59·23	42·37
	131	23 54 53	23 55 19	20 4 29	„	„	57·68	43·40
	132	5 59 20	5 59 47	2 8 57	44 29 24·57	−4 48 52·06	44 30 20·39	−4 54 27·49
	133	6 2 6·5	6 2 33·5	2 11 43·5	„	„	19·10	28·28
XXII.	134	6 7 4	6 7 31	2 16 41	„	„	16·98	29·68
Nov. 13, 1874, morning	135	6 13 34	6 14 1	2 23 11	„	„	14·17	31·50
θ	135 bis	6 16 10	6 16 37	2 25 47	„	„	13·04	32·26
	136	6 17 6·5	6 17 33·5	2 26 43·5	„	„	12·63	32·52
	137	6 20 2·5	6 20 29·5	2 29 39·5	„	„	11·38	33·35
	138	6 24 9·5	6 24 36·5	2 33 46·5	„	„	9·59	34·51
	139	6 35 12	6 35 39	2 44 49	44 29 24·57	−4 48 52·06	44 30 4·84	−4 54 37·64
	140	6 36 25	6 36 52	2 46 2	„	„	4·32	37·98
XXIII.	141	6 40 9	6 40 36	2 49 46	„	„	2·71	39·04
Nov. 13, 1874, morning	142	6 42 31	6 42 58	2 52 8	„	„	1·68	39·72
θ	142 bis	6 45 1	6 45 28	2 54 38	„	„	30 0·60	40·43
	143	7 2 53	7 3 20	3 12 30	„	„	29 52·90	45·48
	144	7 6 55	7 7 22	3 16 32	„	„	51·18	46·62
	145	7 10 41	7 11 8	3 20 18	„	„	49·53	47·67
	146	7 25 38	7 26 5	3 35 15	44 29 24·57	−4 48 52·06	44 29 43·08	−4 54 51·91
	147	7 27 25·5	7 27 52·5	3 37 2·5	„	„	42·32	52·43
XXIV.	148	7 30 25	7 30 52	3 40 2	„	„	41·03	53·26
Nov. 13, 1874, morning	149	7 34 31·5	7 34 58·5	3 44 8·5	„	„	39·26	54 54·91
θ	150*a*	7 56 4·5	7 56 31·5	4 5 41·5	„	„	29·97	55 0·52
	150	7 57 40	7 58 7	4 7 17	„	„	29·28	0·96
	151	7 59 35	8 0 2	4 9 12	„	„	28·48	1·50
	152	8 2 9·5	8 2 36·5	4 11 46·5	„	„	27·35	2·25

Parallax in α	Parallax in Dec.	Distances				Position Angles				Rotation number
		Tabular distance	Par. factor in distance	Factor for change of α	Factor for change of Dec.	Tabular position angle	Par. factor in pos. angle	Factor for change of α	Factor for change of Dec.	
+6″86	+2″54	″	f'''	f'	f''	131° 40′29	−0·689	−7·088	−7·992	118
+6·82	+2·53	322·24	+0·0337	+0·7426	−0·6668	...	...	...	...	119
+6·77	+2·52	321·82	+0·0332	+0·7395	−0·6702	...	...	...	...	120
+6·73	+2·51	...	...	...	...	132 16·97	−0·683	−7·193	−7·928	121
+6·70	+2·50	...	...	...	...	132 26·44	−0·682	−7·220	−7·924	121 bis
+6·68	+2·50	321·14	+0·0321	+0·7341	−0·6762	...	...	...	...	122
+6·57	+2·50	320·51	+0·0309	+0·7291	−0·6816	...	...	...	...	123
+6·51	+2·49	...	...	...	...	133 16·37	−0·675	−7·362	−7·847	124
+6·17	+2·46	...	...	...	...	134 44·95	−0·659	−7·607	−7·702	125
+6·13	+2·46	317·96	+0·0259	+0·7060	−0·7057	...	...	...	...	126
+6·06	+2·45	317·61	+0·0252	+0·7021	−0·7093	...	...	...	...	127
+5·97	+2·44	...	...	...	...	135 33·32	−0·648	−7·739	−7·617	128
+5·94	+2·44	...	...	...	...	135 39·37	−0·646	−7·755	−7·606	128 bis
+5·90	+2·43	316·90	+0·0236	+0·6950	−0·7166	...	...	...	...	129
+5·85	+2·43	316·61	+0·0230	+0·6916	−0·7199	...	...	...	...	130
+5·77	+2·42	...	...	...	...	136 23·20	−0·636	−7·871	−7·526	131
−5·73	+2·41	...	...	...	...	171 29·50	+0·542	−10·097	−1·516	132
−5·80	+2·42	337·31	−0·0323	+0·1434	−0·9896	...	...	...	...	133
−5·91	+2·43	338·38	−0·0322	+0·1364	−0·9906	...	...	...	...	134
−6·07	+2·44	...	...	...	...	172 39·97	+0·578	−10·035	−1·296	135
−6·13	+2·45	...	...	...	...	172 52·81	+0·584	−10·022	−1·256	135 bis
−6·15	+2·45	340·58	−0·0318	+0·1222	−0·9925	...	...	...	...	136
−6·22	+2·46	341·24	−0·0317	+0·1181	−0·9930	...	...	...	...	137
−6·31	+2·47	...	...	...	...	173 31·65	+0·602	−9·983	−1·137	138
−6·55	+2·49	...	...	...	...	174 24·41	+0·626	−9·925	−0·976	139
−6·57	+2·50	345·01	−0·0312	+0·0955	−0·9954	...	...	...	...	140
−6·64	+2·51	345·90	−0·0310	+0·0904	−0·9959	...	...	...	...	141
−6·68	+2·52	...	...	...	...	174 58·77	+0·638	−9·884	−0·872	142
−6·73	+2·52	...	...	...	...	175 10·49	+0·642	−9·853	−0·836	142 bis
−7·06	+2·56	351·50	−0·0298	+0·0601	−0·9982	...	...	...	...	143
−7·12	+2·58	352·52	−0·0297	+0·0549	−0·9985	...	...	...	...	144
−7·19	+2·59	...	...	...	...	177 7·72	+0·686	−9·714	−0·489	145
−7·41	+2·63	...	...	...	...	178 13·60	+0·705	−9·614	−0·299	146
−7·43	+2·64	357·88	−0·0285	+0·0286	−0·9996	...	...	...	...	147
−7·46	+2·65	358·66	−0·0284	+0·0249	−0·9997	...	...	...	...	148
−7·51	+2·66	...	...	...	...	178 51·63	+0·712	−9·554	−0·191	149
−7·76	+2·71	...	...	...	...	182 22·10	+0·731	−9·399	+0·061	150*a*
−7·78	+2·72	366·19	−0·0266	−0·0083	−1·0000	...	...	...	...	150
−7·79	+2·72	366·74	−0·0264	−0·0105	−0·9999	...	...	...	...	151
−7·81	+2·73	...	...	...	...	180 46·89	+0·734	−9·354	+0·126	152

No. of group — Date — Star of comparison	Rotation number	Time by chronometer	Local sidereal time	Greenwich sidereal time	Right ascension of star	Declination of star	Geocentric right ascension of planet	Geocentric declination of planet
		h. m. sec.	h. m. sec.	h. m. sec.	° ′ ″	° ′ ″	° ′ ″	° ′ ″
	153	7 36 19	7 36 46	3 45 56	44 29 24·57	−4 48 52·06	44 29 38·50	−4 54 54·92
	154	7 38 21	7 38 48	3 47 58	,,	,,	37·62	55·50
XXV.	155	7 42 36	7 43 3	3 52 13	,,	,,	35·78	56·71
Nov. 13, 1874, morning	156	7 45 50	7 46 17	3 55 27	,,	,,	34·38	57·62
θ	157	7 47 8·5	7 47 35·5	3 56 45·5	,,	,,	33·82	58·00
	158	7 51 57	7 52 24	4 1 34	,,	,,	31·76	59·35
	159	7 54 8	7 54 35	4 3 45	,,	,,	30·80	59·97
	160	6 53 39	6 54 9	3 3 19	43 6 17·15	−4 42 30·94	44 19 39·54	−5 1 19·13
	161	7 2 36	7 3 6	3 12 16	,,	,,	35·73	21·52
	162	7 7 33	7 8 3	3 17 13	,,	,,	33·62	22·84
XXVI.	163	7 12 31	7 13 1	3 22 11	,,	,,	31·51	24·17
Nov. 14, 1874, morning	163 bis	7 14 7	7 14 37	3 23 47	,,	,,	30·83	24·59
λ	164	7 18 32·5	7 19 2·5	3 28 12·5	,,	,,	28·93	25·77
	165	7 23 46	7 24 16	3 33 26	,,	,,	26·72	27·17
	166	7 27 25	7 27 55	3 37 5	,,	,,	25·16	28·15
	167	7 35 19	7 35 48	3 44 58	45 16 51·50	−5 51 59·61	44 19 21·81	−5 1 30·24
	168	7 36 56	7 37 25	3 46 35	,,	,,	21·11	30·67
	169	7 42 53	7 43 22	3 52 32	,,	,,	18·58	32·27
XXVII.	170	7 48 8	7 48 37	3 57 47	,,	,,	16·35	33·67
Nov. 14, 1874, morning	171	7 50 48	7 51 17	4 0 27	,,	,,	15·20	34·38
ζ	171*a*	7 54 37	7 55 6	4 4 16	,,	,,	13·59	35·40
	172	8 0 8	8 0 37	4 9 47	,,	,,	11·24	36·88
	173	8 3 39	8 4 8	4 13 18	,,	,,	9·73	37·81
	176	23 49 6·5	23 49 38	19 58 48	45 16 51·59	−5 51 59·69	44 12 28·77	−5 5 44·95
	177	23 50 14	23 50 45·5	19 59 55·5	,,	,,	28·30	45·24
	178	23 53 16	23 53 47·5	20 2 57·5	,,	,,	27·01	46·01
XXVIII.	179	23 55 24·5	23 55 56	20 5 6	,,	,,	26·12	46·56
Nov. 15, 1874, evening	180	23 57 16·5	23 57 48	20 6 58	,,	,,	25·33	47·04
ζ	181	23 58 26·5	23 58 58	20 8 8	,,	,,	24·83	47·35
	182	0 1 43	0 2 14·5	20 11 24·5	,,	,,	23·46	48·18
	183	0 6 24·5	0 7 56	20 17 6	,,	,,	21·06	49·62
	184	0 15 37	0 16 8·5	20 25 18·5	43 6 17·22	−4 42 31·02	44 12 17·58	−5 5 51·73
	185	0 17 30	0 18 1·5	20 27 11·5	,,	,,	16·80	52·20
	186	0 20 50·5	0 21 22	20 30 32	,,	,,	15·39	53·06
XXIX.	187	0 23 40	0 24 11·5	20 33 21·5	,,	,,	14·19	53·79
Nov. 15, 1874, evening	187 bis	0 25 22	0 25 53·5	20 35 3·5	,,	,,	13·48	54·23
λ	188	0 31 27	0 31 58·5	20 41 8·5	,,	,,	10·91	55·79
	189	0 36 6·5	0 36 38	20 45 48	,,	,,	8·94	56·98
	190	0 39 26	0 39 57·5	20 49 7·5	,,	,,	7·53	57·82

Parallax in AR	Parallax in Dec.	Distances				Position Angles				Rotation number
		Tabular distance	Par. factor in distance	Factor for change of AR	Factor for change of Dec.	Tabular position angle	Par. factor in pos. angle	Factor for change of AR	Factor for change of Dec.	
		"	*f'''*	*f'*	*f''*	° ′	*f'''*	*f'*	*f''*	
−7".53	+2".66	...	...	...	...	178 59.14	+0.714	−9.541	−0.170	153
−7.57	+2.66	360.82	−0.0277	+0.0151	−0.9999	...	...	...	...	154
−7.62	+2.67	362.00	−0.0274	+0.0098	−1.0000	...	...	...	...	155
−7.66	+2.68	...	...	...	...	179 39.71	+0.724	−9.473	−0.056	156
−7.67	+2.69	363.25	−0.0272	+0.0043	−1.0000	...	...	...	...	157
−7.72	+2.70	364.59	−0.0269	−0.0014	−1.0000	...	...	...	...	158
−7.74	+2.71	...	...	...	...	180 14.16	+0.730	−9.413	−0.039	159
−6.90	+2.53	...	...	...	...	104 24.82	−0.006	−0.189	−0.739	160
−7.04	+2.55	4518.77	−0.0743	+0.9649	−0.2496	...	...	...	...	161
−7.13	+2.57	4516.97	−0.0752	+0.9647	−0.2500	...	...	...	...	162
−7.21	+2.58	...	...	...	...	104 30.08	−0.005	−0.191	−0.740	163
−7.23	+2.59	...	...	...	...	104 30.51	−0.006	−0.191	−0.740	163 bis
−7.31	+2.60	4513.00	−0.0770	+0.9645	−0.2509	...	...	...	...	164
−7.38	+2.61	4511.15	−0.0778	+0.9644	−0.2513	...	...	...	...	165
−7.43	+2.62	...	...	...	...	104 34.23	−0.005	−0.192	−0.740	166
−7.53	+2.64	...	...	...	...	311 22.72	−0.022	+0.495	+0.565	167
−7.55	+2.65	4586.95	+0.0739	−0.7471	+0.6609	...	...	...	...	168
−7.61	+2.67	4587.83	+0.0745	−0.7475	+0.6605	...	...	...	...	169
−7.66	+2.68	...	...	...	...	311 18.06	−0.023	+0.494	+0.565	170
−7.70	+2.69	...	...	...	...	311 17.08	−0.023	+0.494	+0.565	171
−7.73	+2.70	4589.60	+0.0755	−0.7483	+0.6595	...	...	...	...	171*a*
−7.78	+2.72	4590.42	+0.0761	−0.7487	+0.6591	...	...	...	...	172
−7.81	+2.73	...	...	...	...	311 12.43	−0.023	+0.493	+0.566	173
+5.84	+2.40	...	...	...	...	305 52.72	+0.039	+0.425	+0.591	176
+5.81	+2.40	4738.68	−0.0328	−0.8065	+0.5860	...	...	...	...	177
+5.74	+2.39	4739.32	−0.0323	−0.8068	+0.5858	...	...	...	...	178
+5.69	+2.38	...	...	...	...	305 50.57	+0.038	+0.425	+0.591	179
+5.64	+2.38	...	...	...	...	305 49.94	+0.038	+0.425	+0.591	180
+5.61	+2.37	4740.39	−0.0314	−0.8071	+0.5853	...	...	...	...	181
+5.53	+2.37	4741.07	−0.0307	−0.8072	+0.5851	...	...	...	...	182
+5.39	+2.36	...	...	...	...	305 46.50	+0.037	+0.424	+0.591	183
+5.17	+2.34	...	...	...	...	109 29.38	−0.032	−0.274	−0.776	184
+5.12	+2.34	4190.55	+0.0403	+0.9392	−0.3338	...	...	...	...	185
+5.02	+2.33	4189.42	+0.0393	+0.9391	−0.3341	...	...	...	...	186
+4.94	+2.32	...	...	...	...	109 31.97	−0.032	−0.275	−0.776	187
+4.90	+2.32	...	...	...	...	109 32.52	−0.031	−0.275	−0.776	187 bis
+4.73	+2.31	4185.86	+0.0367	+0.9388	−0.3351	...	...	...	...	188
+4.60	+2.30	4184.29	+0.0355	+0.9386	−0.3355	...	...	...	...	189
+4.51	+2.30	...	...	...	...	109 37.05	−0.030	−0.276	−0.777	190

No. of group — Date — Star of comparison	Rotation number	Time by chronometer	Local sidereal time	Greenwich sidereal time	Right ascension of star	Declination of star	Geocentric right ascension of planet	Geocentric declination of planet
		h. m. sec.	h. m. sec.	h. m. sec.	° ′ ″	° ′ ″	° ′ ″	° ′ ″
	191	0 44 29·5	0 45 1	20 54 11	43 6 17·22	−4 42 31·02	44 12 5·41	−5 5 59·11
	192	0 46 7	0 46 38·5	20 55 48·5	,,	,,	4·72	5 59·55
	193	0 50 57	0 51 28·5	21 0 38·5	,,	,,	2·68	6 0·76
XXX.	194	0 54 18	0 54 49·5	21 3 59·5	,,	,,	1·26	1·62
Nov. 15, 1874, evening	194 bis	0 55 37·5	0 56 9	21 5 19	,,	,,	0·70	1·96
λ	195	0 56 42	0 57 13·5	21 6 23·5	,,	,,	12 0·25	2·23
	196	0 59 38	1 0 9·5	21 9 19·5	,,	,,	11 59·01	2·99
	197	1 3 34·5	1 4 6	21 13 16	,,	,,	57·35	3·99
	198	1 8 57·5	1 9 29	21 18 39	45 16 51·59	−5 51 59·70	44 11 55·07	−5 6 5·36
	199	1 9 55	1 10 26·5	21 19 36·5	,,	,,	54·67	5·60
XXXI.	200	1 13 34·5	1 14 6	21 23 16	,,	,,	53·13	6·54
Nov. 15, 1874, evening	201	1 16 50	1 17 21·5	21 26 31·5	,,	,,	51·76	7·38
ζ	202	1 17 59	1 18 30·5	21 28 40·5	,,	,,	51·30	7·91
	203	1 21 45·5	1 22 17	21 31 27	,,	,,	49·68	8·64
	204	1 24 28·5	1 25 0	21 34 10	,,	,,	48·52	9·32
	205	5 25 49	5 26 21	1 35 31	45 16 51·60	−5 51 59·72	44 10 6·86	−5 7 10·59
	206	5 27 46·5	5 28 18·5	1 37 28·5	,,	,,	6·02	11·09
XXXII.	207	5 31 21	5 31 53	1 41 3	,,	,,	4·53	11·99
Nov. 15, 1874, morning	208	5 35 2	5 35 34	1 44 44	,,	,,	3·01	12·92
ζ	209	5 37 9	5 37 41	1 46 51	,,	,,	2·10	13·45
	210	5 38 57	5 39 29	1 48 39	,,	,,	10 1·32	13·91
	211	5 43 9	5 43 41	1 52 51	,,	,,	9 59·57	14·96
	212	5 46 45·5	5 47 17·5	1 56 27·5	,,	,,	58·04	15·88
	213	5 53 30	5 54 1·5	2 3 11·5	43 6 17·25	−4 42 31·04	44 9 55·22	−5 7 17·57
	214	5 55 10	5 55 41·5	2 4 51·5	,,	,,	54·52	17·99
	215	5 58 57	5 59 28·5	2 8 38·5	,,	,,	52·91	18·94
XXXIII.	216	6 2 23	6 2 54·5	2 12 4·5	,,	,,	51·48	19·81
Nov. 15, 1874, morning	217	6 4 50	6 5 21·5	2 14 31·5	,,	,,	50·45	20·42
λ	218	6 7 7	6 7 38·5	2 16 48·5	,,	,,	49·49	21·00
	219	6 11 30	6 12 1·5	2 21 11·5	,,	,,	47·64	22·11
	220	6 14 43	6 15 14·5	2 24 24·5	,,	,,	46·29	22·92
	221	6 21 11	6 21 42·5	2 30 52·5	43 6 17·25	−4 42 31·04	44 9 43·58	−5 7 24·55
	222	6 24 13·5	6 24 45	2 33 55	,,	,,	42·28	25·31
	223	6 27 36	6 28 7·5	2 37 17·5	,,	,,	40·86	26·17
XXXIV.	224	6 30 40	6 31 11·5	2 40 21·5	,,	,,	39·59	26·92
Nov. 15, 1874, morning	225	6 33 15	6 33 46·5	2 42 56·5	,,	,,	38·50	27·58
λ	226 bis	6 38 49	6 39 20·5	2 48 30·5	,,	,,	36·15	28·98
	227	6 44 9·5	6 44 41	2 53 51	,,	−4 42 31·05	33·91	30·32
	228	6 46 43	6 47 14·5	2 56 24·5	,,	,,	32·83	30·98

Parallax in α	Parallax in Dec.	Distances				Position Angles				Rotation number
		Tabular distance	Par. factor in distance	Factor for change of α	Factor for change of Dec.	Tabular position angle	Par. factor in pos. angle	Factor for change of α	Factor for change of Dec.	
		"	f'''	f'	f''	° ′	f'''	f'	f''	
+4·36	+2·29	...	...	...	...	109 38·68	−0·030	−0·276	−0·777	191
+4·32	+2·29	4180·94	+0·0328	+0·9383	−0·3363	...	...	...	...	192
+4·18	+2·28	4179·30	+0·0315	+0·9381	−0·3368	...	...	...	...	193
+4·07	+2·27	...	...	...	...	109 41·87	−0·029	−0·277	−0·778	194
+4·04	+2·27	...	...	...	...	109 42·30	−0·029	−0·278	−0·778	194 bis
+4·01	+2·27	4177·36	+0·0299	+0·9379	−0·3373	...	...	...	...	195
+3·93	+2·26	4176·38	+0·0293	+0·9379	−0·3375	...	...	...	...	196
+3·82	+2·25	...	...	...	...	109 44·87	−0·028	−0·278	−0·778	197
+3·62	+2·25	...	...	...	...	305 25·54	+0·029	+0·420	+0·590	198
+3·59	+2·25	4755·72	−0·0160	−0·8102	+0·5810	...	...	...	...	199
+3·47	+2·24	4756·52	−0·0151	−0·8104	+0·5807	...	...	...	...	200
+3·36	+2·24	...	...	...	...	305 22·85	+0·027	+0·419	+0·591	201
+3·29	+2·23	4757·48	−0·0138	−0·8107	+0·5803	...	...	...	...	202
+3·21	+2·23	4758·30	−0·0131	−0·8109	+0·5800	...	...	...	...	203
+3·12	+2·22	...	...	...	...	305 20·26	+0·026	+0·418	+0·591	204
−4·87	+2·32	...	...	...	...	303 59·56	−0·006	+0·399	+0·595	205
−4·92	+2·32	4814·32	+0·0536	−0·8254	+0·5590	...	...	...	...	206
−5·00	+2·33	4815·12	+0·0543	−0·8256	+0·5587	...	...	...	...	207
−5·10	+2·33	...	...	...	...	303 56·56	−0·006	+0·399	+0·595	208
−5·15	+2·34	...	...	...	...	303 55·87	−0·007	+0·398	+0·595	209
−5·22	+2·34	4816·89	+0·0562	−0·8260	+0·5581	...	...	...	...	210
−5·33	+2·35	4817·84	+0·0571	−0·8262	+0·5578	...	...	...	...	211
−5·43	+2·36	...	...	...	...	303 52·73	−0·008	+0·398	+0·595	212
−5·61	+2·37	...	...	...	...	110 20·52	−0·002	−0·307	−0·788	213
−5·64	+2·38	4077·47	−0·0610	+0·9279	−0·3641	...	...	...	...	214
−5·73	+2·38	4076·24	−0·0619	+0·9278	−0·3644	...	...	...	...	215
−5·81	+2·39	...	...	...	..	111 23·47	−0·001	−0·308	−0·788	216
−5·87	+2·39	...	...	...	...	111 24·28	−0·001	−0·308	−0·789	217
−5·92	+2·40	4073·63	−0·0637	+0·9275	−0·3652	...	...	...	...	218
−6·03	+2·41	4072·22	−0·0647	+0·9273	−0·3656	...	.	...	...	219
−6·10	+2·42	...	...	...	...	111 27·57	0·000	−0·309	−0·789	220
−6·25	+2·43	...	...	...	...	111 29·72	0·000	−0·310	−0·789	221
−6·32	+2·44	4068·14	−0·0674	+0·9269	−0·3667	...	...	...	...	222
−6·39	+2·45	4067·08	−0·0682	+0·9268	−0·3670	...	...	...	...	223
−6·46	+2·46	...	...	...	...	111 32·86	+0·001	−0·311	−0·789	224
−6·51	+2·47	...	...	...	...	111 33·74	+0·001	−0·311	−0·789	225
−6·62	+2·48	4063·51	−0·0704	+0·9264	−0·3680	...	...	...	...	226 bis
−6·72	+2·49	4061·83	−0·0714	+0·9262	−0·3685	...	...	...	...	227
−6·77	+2·50	...	...	...	...	111 38·21	+0·001	−0·312	−0·790	228

No. of group — Date — Star of comparison	Rotation number	Time by chronometer	Local sidereal time	Greenwich sidereal time	Right ascension of star	Declination of star	Geocentric right ascension of planet	Geocentric declination of planet
		h. m. sec.	h. m. sec.	h. m. sec.	° ′ ″	° ′ ″	° ′ ″	° ′ ″
	229	6 54 25	6 54 57	3 4 7	45 16 51·61	−5 51 59·73	44 9 29·58	−5 7 32·91
	230	6 57 1	6 57 33	3 6 43	,,	,,	28·49	33·57
	231	7 1 24·5	7 1 56·5	3 11 6·5	,,	,,	26·65	34·68
XXXV.	232	7 4 28	7 5 0	3 14 10	,,	,,	25·36	35·43
Nov. 15, 1874, morning	233	7 8 17	7 8 49	3 17 59	,,	,,	23·75	36·39
ζ	234	7 9 42	7 10 14	3 19 24	,,	,,	23·15	36·76
	235	7 14 50	7 15 22	3 24 32	,,	,,	21·01	38·05
	236	7 18 32	7 19 4	3 28 14	,,	,,	19·45	38·98
	237	7 21 2	7 21 34	3 30 44	45 16 51·61	−5 51 59·73	44 9 18·40	−5 7 39·61
	238	7 22 30·5	7 23 2·5	3 32 12·5	,,	,,	17·78	39·98
XXXVI.	239	7 26 20	7 26 52	3 36 2	,,	,,	16·18	40·95
Nov. 15, 1874, morning	240	7 29 42	7 30 14	3 39 24	,,	,,	14·76	41·79
ζ	241	7 31 15	7 31 47	3 40 57	45 16 51·62	,,	14·11	42·19
	242	7 36 35	7 37 7	3 46 17	,,	,,	11·87	43·52
	243	7 39 30	7 40 2	3 49 12	,,	,,	10·65	47·24
	244	7 58 35	7 59 6·5	4 8 16·5	43 6 17·25	−4 42 31·05	44 9 2·64	−5 7 49·02
XXXVII.	245	8 0 15	8 0 46·5	4 9 56·5	,,	,,	1·93	49·45
Nov. 15, 1874, morning	246	8 4 0	8 4 31·5	4 13 41·5	,,	,,	9 0·37	50·37
λ	247	8 8 19	8 8 50·5	4 18 0·5	,,	,,	8 58·54	51·46
	248	23 10 16	23 10 53	19 19 3	44 28 32·07	−5 43 55·18	43 43 4·75	−5 17 7·77
	249	23 13 44	23 14 21	19 23 31	,,	,,	2·96	8·76
	250	23 18 16	23 18 53	19 28 3	,,	,,	1·14	9·78
XXXVIII.	251	23 20 52·5	23 21 29·5	19 30 39·5	,,	,,	43 0·09	10·36
Nov. 17, 1874, evening	252	23 23 37	23 24 14	19 33 24	,,	,,	42 58·90	10·98
ι	253	23 24 46	23 25 23	19 34 33	,,	,,	58·53	11·24
	254	23 32 11	23 32 48	19 41 58	,,	,,	55·56	12·90
	255	23 35 41·5	23 36 18·5	19 45 28·5	,,	,,	54·16	13·69
	256	22 52 25	22 53 5	19 2 15	44 29 25·07	−4 48 52·56	43 43 11·49	−5 22 15·89
	257	22 53 56	22 54 36	19 3 46	,,	,,	10·88	16·20
	258	22 56 23	22 57 3	19 6 13	,,	,,	9·89	16·71
XXXIX.	259	23 11 29	23 12 9	19 21 19	,,	,,	3·82	19·86
Nov. 18, 1874, evening	260	23 14 21·5	23 15 1·5	19 24 11·5	,,	,,	2·70	20·44
θ	261	23 19 54·5	23 20 34·5	19 29 44·5	,,	,,	43 0·46	21·61
	262	23 23 37	23 24 17	19 33 27	,,	,,	42 58·97	22·38
	263	23 28 17·5	23 38 57·5	19 38 7·5	,,	,,	57·09	23·35
	264	5 32 18	5 32 58	1 42 8	44 29 25·08	−4 48 52·59	43 40 31·60	−5 23 38·33
	265	5 35 30	5 36 10	1 45 20	,,	,,	30·33	38·98
	266	5 41 7	5 41 47	1 50 57	,,	,,	28·09	40·13
XL.	267	5 43 58	5 44 38	1 53 48	,,	,,	26·96	40·72
Nov. 18, 1874, morning	268	5 45 15	5 45 55	1 55 5	,,	,,	26·45	40·98
θ	269	5 46 52	5 47 32	1 56 42	,,	,,	25·80	41·31
	270	5 51 2	5 51 42	2 0 52	,,	,,	24·14	42·15
	271	5 55 56	5 56 36	2 5 46	,,	,,	22·18	43·14

Parallax in AR	Parallax in Dec.	Distances				Position Angles				Rotation number
		Tabular distance	Par. factor in distance	Factor for change of AR	Factor for change of Dec.	Tabular position angle	Par. factor in pos. angle	Factor for change of AR	Factor for change of Dec.	
		"	f'''	f'	f''	° ′	f'''	f'	f''	
−6·92	+2·52	...	...	...	...	303 30·96	−0·012	+0·393	+0·596	229
−6·95	+2·52	4834·69	+0·0716	−0·8300	+0·5520	...	...	...	...	230
−7·03	+2·54	4835·68	+0·0723	−0·8302	+0·5517	...	...	...	...	231
−7·08	+2·55	...	...	...	...	303 27·77	−0·013	+0·392	+0·596	232
−7·14	+2·56	...	...	...	...	303 26·56	−0·013	+0·392	+0·596	233
−7·16	+2·57	4837·57	+0·0736	−0·8306	+0·5510	...	...	...	...	234
−7·24	+2·58	4838·72	+0·0743	−0·8309	+0·5506	...	...	...	...	235
−7·29	+2·59	...	...	...	...	303 22·31	−0·013	+0·391	+0·596	236
−7·33	+2·60	...	...	...	...	303 22·51	−0·013	+0·391	+0·596	237
−7·35	+2·60	4840·43	+0·0754	−0·8313	+0·5500	...	...	...	...	238
−7·40	+2·61	4841·27	+0·0758	−0·8315	+0·5497	...	...	...	...	239
−7·45	+2·62	...	...	...	...	303 19·77	−0·014	+0·390	+0·596	240
−7·47	+2·62	4842·38	+0·0772	−0·8320	+0·5490	...	...	...	...	241
−7·54	+2·64	4843·58	+0·0775	−0·8321	+0·5487	...	...	...	...	242
−7·57	+2·65	...	...	...	...	303 16·69	−0·014	+0·389	+0·596	243
−7·76	+2·70	...	...	...	...	112 2·08	+0·003	−0·319	−0·792	244
−7·77	+2·70	4038·30	−0·082	+0·9235	−0·3753	...	...	...	...	245
−7·81	+2·72	4037·16	−0·082	+0·9233	−0·3757	...	...	...	...	246
−7·84	+2·73	...	...	...	...	112 5·31	+0·004	−0·320	−0·792	247
+6·62	+2·46	...	...	...	...	300 43·75	+0·060	+0·558	+0·942	248
+6·53	+2·45	3151·60	−0·0434	−0·8559	+0·5105	...	...	...	...	249
+6·45	+2·44	3152·70	−0·0428	−0·8562	+0·5100	...	...	...	...	250
+6·40	+2·43	...	...	...	...	300 38·59	+0·058	+0·556	+0·942	251
+6·34	+2·42	...	...	...	...	300 37·36	+0·058	+0·555	+0·942	252
+6·32	+2·42	3154·29	−0·0418	−0·8566	+0·5093	...	...	...	...	253
+6·18	+2·40	3156·10	−0·0408	−0·8571	+0·5084	...	...	...	...	254
+6·08	+2·39	...	...	...	...	300 31·98	+0·056	+0·553	+0·942	255
+6·92	+2·49	...	...	...	...	234 1·11	−0·021	−0·593	+0·820	256
+6·89	+2·49	3406·19	−0·0701	−0·8060	−0·5875	...	...	...	...	257
+6·85	+2·48	3407·33	−0·0698	−0·8060	−0·5875	...	...	...	...	258
+6·57	+2·44	...	...	...	...	234 2·56	−0·019	−0·591	+0·818	259
+6·51	+2·43	...	...	...	...	234 2·77	−0·019	−0·591	+0·818	260
+6·40	+2·42	3418·20	−0·0659	−0·8063	−0·5870	...	...	...	...	261
+6·33	+2·41	3419·92	−0·0651	−0·8064	−0·5870	...	...	...	...	262
+6·24	+2·40	...	...	...	...	234 3·84	−0·017	−0·590	+0·817	263
−5·07	+2·28	...	...	...	...	234 33·36	+0·046	−0·555	+0·783	264
−5·15	+2·29	3594·16	+0·0285	−0·8115	−0·5799	...	...	...	...	265
−5·28	+2·30	3596·75	+0·0294	−0·8115	−0·5798	...	...	...	...	266
−5·35	+2·31	...	...	...	...	234 34·24	+0·048	−0·554	+0·782	267
−5·40	+2·31	...	...	...	...	234 35·35	+0·048	−0·554	+0·782	268
−5·42	+2·31	3599·40	+0·0306	−0·8116	−0·5797	...	...	...	...	269
−5·52	+2·32	3601·31	+0·0313	−0·8117	−0·5796	...	...	...	...	270
−5·67	+2·33	...	...	...	...	234 35·19	+0·050	−0·553	+0·781	271

No. of group — Date — Star of comparison	Rotation number	Time by chronometer	Local sidereal time	Greenwich sidereal time	Right ascension of star	Declination of star	Geocentric right ascension of planet	Geocentric declination of planet
		h. m. sec.	h. m. sec.	h. m. sec.	° ′ ″	° ′ ″	° ′ ″	° ′ ″
	272	6 5 31	6 6 11	2 15 21	42 37 14·04	−5 51 22·72	43 40 18·37	−5 23 45·09
	273	6 7 4	6 7 44	2 16 54	,,	,,	17·75	45·42
	274	6 12 25	6 13 5	2 22 15	,,	,,	15·62	46·51
XLI.	275	6 21 21	6 22 1	2 31 11	,,	,,	12·07	48·32
Nov. 18, 1874, morning	276	6 24 21	6 25 1	2 34 11	,,	,,	10·88	48·94
μ	277	6 25 31	6 26 11	2 35 21	,,	,,	10·40	49·16
	278	6 29 46·5	6 30 26·5	2 39 36·5	,,	,,	8·71	50·06
	279	6 33 59·5	6 34 39·5	2 43 49·5	,,	,,	7·03	50·91
	280	6 41 4	6 41 44	2 50 54	42 37 14·04	−5 51 22·72	43 40 4·21	−5 23 52·34
	281	6 42 15	6 42 55	2 52 5	42 37 14·05	−5 51 22·73	3·74	52·60
	282	6 46 28	6 47 8	2 56 18	,,	,,	2·05	53·43
XLII.	283	6 50 19	6 50 59	3 0 9	,,	,,	40 0·52	54·22
Nov. 18, 1874, morning	284	6 52 41·5	6 53 21·5	3 2 31·5	,,	,,	39 59·60	54·70
μ	285	6 53 54	6 54 34	3 3 44	,,	,,	59·11	54·95
	286	6 58 9	6 58 49	3 7 59	,,	,,	57·48	55·82
	287	7 2 59	7 3 39	3 12 49	,,	,,	55·49	56·79
	288	7 12 19	7 12 59	3 22 9	44 29 25·09	−4 48 52·60	43 39 51·76	−5 23 58·69
	289	7 13 21·5	7 14 1·5	3 23 11·5	,,	,,	51·38	58·89
	290	7 16 48·5	7 17 28·5	3 26 38·5	,,	,,	49·98	23 59·60
XLIII.	291	7 20 23	7 21 3	3 30 13	,,	,,	48·56	24 0·31
Nov. 18, 1874, morning	292	7 23 5·5	7 23 45·5	3 32 55·5	,,	,,	47·50	0·87
θ	293	7 25 14	7 25 54	3 35 4	,,	,,	46·64	1·31
	294	7 30 10	7 30 50	3 40 0	,,	,,	44·69	2·30
	295	7 34 3·5	7 34 43·5	3 43 53·5	,,	,,	43·15	3·10
	296	23 33 40	23 34 21	19 43 31	44 29 25·15	−4 48 52·67	43 33 24·15	−5 27 12·17
	297	23 35 23	23 36 4	19 45 14	,,	,,	23·46	12·50
	298	23 39 19	23 40 0	19 49 10	,,	,,	21·93	13·26
XLIV.	299	23 42 48	23 43 29	19 52 39	,,	,,	20·57	13·94
Nov. 19, 1874, evening	300	23 43 53	23 44 34	19 53 44	,,	,,	20·15	14·14
θ	301	23 46 6·5	23 46 48	19 55 58	,,	,,	19·27	14·56
	302	23 49 15·5	23 49 57	19 59 7	,,	,,	18·03	15·17
	303	23 52 31	23 53 12	20 2 22	,,	,,	16·77	15·79
	304	0 1 35	0 2 16	20 11 26	42 37 14·10	−5 51 22·80	43 33 13·20	−5 27 17·53
	305	0 2 59	0 3 40	20 12 50	,,	,,	12·65	17·80
	306	0 7 0	0 7 41	20 16 51	,,	,,	11·08	18·56
XLV.	307	0 10 7	0 10 48	20 19 58	,,	,,	9·86	19·15
Nov. 19, 1874, evening	308	0 12 50·5	0 13 32	20 22 42	,,	,,	8·80	19·69
μ	309	0 14 51	0 15 32	20 24 42	,,	,,	8·03	20·07
	310	0 18 58	0 19 39	20 28 49	,,	,,	6·41	20·85
	311	0 22 36·5	0 23 18	20 32 28	,,	,,	4·97	21·54

Parallax in AR	Parallax in Dec.	Distances				Position Angles				Rotation number
		Tabular distance	Par. factor in distance	Factor for change of AR	Factor for change of Dec.	Tabular position angle	Par. factor in pos. angle	Factor for change of AR	Factor for change of Dec.	
			f'''	*f'*	*f''*		*f'''*	*f'*	*f'*	
−5".90	+2".35	..."	...	...	...	66° 10'.88	−0'.038	+0'.338	−0'.769	272
−5.93	+2.35	4109.60	−0.0445	+0.9104	+0.4039	...	...	...	...	273
−6.04	+2.37	4107.13	−0.0454	+0.9104	+0.4038	...	...	...	...	274
−6.25	+2.40	...	...	...	...	66 11.07	−0.040	+0.338	−0.770	275
−6.31	+2.41	...	...	...	...	66 11.12	−0.040	+0.339	−0.771	276
−6.33	+2.41	4101.06	−0.0479	+0.9104	+0.4038	...	...	...	...	277
−6.42	+2.42	4099.07	−0.0486	+0.9104	+0.4038	...	...	...	...	278
−6.51	+2.43	...	...	...	...	66 11.25	−0.041	+0.339	−0.771	279
−6.61	+2.44	...	...	...	...	66 11.35	−0.041	+0.339	−0.772	280
−6.65	+2.45	4093.32	−0.0506	+0.9105	+0.4037	...	...	...	...	281
−6.75	+2.46	4091.36	−0.0515	+0.9105	+0.4037	...	...	...	...	282
−6.83	+2.47	...	...	...	...	66 11.45	−0.042	+0.339	−0.773	283
−6.87	+2.48	...	...	...	...	66 11.48	−0.042	+0.340	−0.773	284
−6.90	+2.49	4087.94	−0.0528	+0.9105	+0.4037	...	...	...	...	285
−6.96	+2.50	4086.06	−0.0532	+0.9105	+0.4037	...	...	...	...	286
−7.06	+2.52	...	...	...	...	66 11.61	−0.044	+0.340	−0.774	287
−7.18	+2.54	...	...	...	...	234 40.79	+0.059	−0.546	+0.774	288
−7.19	+2.54	3638.83	+0.0437	−0.8127	−0.5782	...	...	...	...	289
−7.28	+2.55	3640.40	+0.0440	−0.8127	−0.5781	...	...	...	...	290
−7.29	+2.56	...	...	...	...	234 41.36	+0.060	−0.546	+0.773	291
−7.32	+2.57	...	...	...	...	234 41.53	+0.060	−0.545	+0.773	292
−7.36	+2.58	3644.19	+0.0449	−0.8128	−0.5780	...	...	...	...	293
−7.42	+2.59	3646.39	+0.0453	−0.8129	−0.5779	...	...	...	...	294
−7.47	+2.60	...	...	...	...	234 42.27	+0.061	−0.545	+0.772	295
+6.08	+2.37	...	...	...	...	235 29.62	−0.013	−0.480	+0.702	296
+6.03	+2.36	4055.68	−0.0629	−0.8208	−0.5665	...	...	...	...	297
+5.95	+2.35	4057.44	−0.0621	−0.8208	−0.5664	...	...	...	...	298
+5.87	+2.34	...	...	...	...	235 30.17	−0.012	−0.480	+0.701	299
+5.84	+2.34	...	...	...	...	235 30.25	−0.012	−0.480	+0.701	300
+5.79	+2.33	4060.50	−0.0607	−0.8208	−0.5663	...	...	...	...	301
+5.71	+2.33	4061.91	−0.0601	−0.8208	−0.5663	...	...	...	...	302
+5.64	+2.32	...	...	...	...	235 30.79	−0.011	−0.479	+0.700	303
+5.41	+2.30	...	...	...	...	66 37.15	0.000	+0.374	−0.869	304
+5.37	+2.30	3647.01	+0.0581	+0.9134	+0.3968	...	...	...	...	305
+5.27	+2.29	3645.18	+0.0572	+0.9134	+0.3968	...	...	...	...	306
+5.19	+2.28	...	...	...	...	66 37.25	0.000	+0.374	−0.870	307
+5.12	+2.28	...	...	...	...	66 37.29	−0.001	+0.375	−0.871	308
+5.07	+2.28	3641.61	+0.0553	+0.9134	+0.3968	...	...	...	...	309
+4.96	+2.27	3639.70	+0.0543	+0.9134	+0.3968	...	...	...	...	310
+4.86	+2.26	...	...	...	...	66 37.39	−0.002	+0.375	−0.872	311

No. of group — Date — Star of comparison	Rotation number	Time by chronometer	Local sidereal time	Greenwich sidereal time	Right ascension of star	Declination of star	Geocentric right ascension of planet	Geocentric declination of planet
		h. m. sec.	h. m. sec.	h. m. sec.	° ′ ″	° ′ ″	° ′ ″	° ′ ″
	312	0 29 7	0 29 48	20 38 58	42 37 14·10	−5 51 22·80	43 33 2·42	−5 27 22·78
	313	0 30 54	0 31 35	20 40 45	,,	,,	1·73	23·13
	314	0 35 0	0 35 41	20 44 51	42 37 14·11	−5 51 22·81	33 0·12	23·90
XLVI.	315	0 37 53	0 38 34	20 47 44	,,	,,	32 58·99	24·46
Nov. 19, 1874, evening	316	0 40 20	0 41 1	20 50 11	,,	,,	58·03	24·92
μ	317	0 41 40	0 42 21	20 51 31	,,	,,	57·51	25·18
	318	0 45 8·5	0 45 50	20 55 0	,,	,,	56·15	25·84
	319	0 47 39·5	0 48 21	20 57 31	,,	,,	55·16	26·32
	320	0 52 52	0 53 33	21 2 43	44 29 25·16	−4 48 52·68	43 32 53·14	−5 27 27·31
	321	0 54 17	0 54 58	21 4 8	,,	,,	52·60	27·59
	322	0 59 33·5	1 0 15	21 9 25	,,	,,	50·51	28·59
XLVII.	323	1 1 58	1 2 39	21 11 49	,,	,,	49·56	29·05
Nov. 19, 1874, evening	324	1 3 11	1 3 52	21 13 2	,,	,,	49·09	29·27
θ	325	1 4 24	1 5 5	21 14 15	,,	,,	48·62	29·51
	326	1 7 49	1 8 30	21 17 40	,,	,,	47·29	30·16
	327	1 11 15	1 11 56	21 21 6	,,	,,	45·94	30·82
	328	23 4 21·5	23 5 6	19 14 16	44 28 32·34	−5 43 55·52	43 24 17·80	−5 31 31·17
	329	23 7 6	23 7 50	19 17 0	,,	,,	16·78	31·55
	330	23 9 40·5	23 10 25	19 19 35	,,	,,	15·78	32·00
XLVIII.	331	23 15 9	23 15 53	19 25 3	,,	,,	13·69	32·96
Nov. 20, 1874, evening	332	23 17 33	23 18 17	19 27 27	,,	,,	12·77	33·38
ι	333	23 18 39	23 19 23	19 28 33	,,	,,	12·34	33·58
	334	23 22 40·5	23 23 25	19 32 35	,,	,,	10·80	34·29
	335	23 27 12	23 27 56	19 37 6	,,	,,	9·08	35·08
	336	23 33 30	23 34 14	19 43 24	42 6 30·90	−5 50 20·65	43 24 6·67	−5 31 36·20
	337	23 36 0	23 36 44	19 45 54	,,	,,	5·72	36·62
	338	23 41 51·5	23 42 36	19 51 46	,,	,,	3·48	37·65
XLIX.	339	23 45 42·5	23 46 27	19 55 37	,,	,,	2·01	38·33
Nov. 20, 1874, evening	340	23 50 4	23 50 48	19 59 58	,,	,,	24 0·34	39·09
ν	341	23 53 42·5	23 54 27	20 3 37	,,	,,	23 58·94	39·72
	342	23 58 23·5	23 59 8	20 8 18	,,	,,	57·15	40·54
	343	0 3 44	0 4 28	20 13 38	,,	,,	55·11	41·47
	344	6 2 25	6 3 10	2 12 20	44 28 32·37	−5 43 55·55	43 21 38·49	−5 32 43·44
	345	6 5 0	6 5 45	2 14 55	,,	,,	37·50	43·86
	346	6 9 15	6 10 0	2 19 10	,,	,,	35·88	44·59
L.	347	6 19 9	6 19 54	2 29 4	,,	,,	32·13	46·28
Nov. 20, 1874, morning	348	6 22 23	6 23 8	2 32 18	,,	,,	30·91	46·84
ι	349	6 24 37	6 25 22	2 34 32	,,	,,	30·06	47·22
	350	6 29 22	6 30 7	2 39 17	,,	,,	28·25	48·03
	351	6 32 53	6 33 38	2 42 48	,,	,,	26·92	48·61

Parallax in α	Parallax in Dec.	Distances				Position Angles				Rotation number
		Tabular distance	Par. factor in distance	Factor for change of α	Factor for change of Dec.	Tabular position angle	Par factor in pos. angle	Factor for change of α	Factor for change of Dec.	
		"	f'''	f'	f''	° ′	f'''	f'	f''	
+4·68	+2·25	...	...	...	...	66 37·45	−0·002	+0·375	−0·872	312
+4·63	+2·24	3634·22	+0·0512	+0·9134	+0·3968	...	...	...	...	313
+4·52	+2·23	3632·33	+0·0501	+0·9134	+0·3968	...	...	...	...	314
+4·43	+2·23	...	...	...	...	66 37·54	−0·003	+0·376	−0·873	315
+4·36	+2·22	...	...	...	...	66 37·56	−0·003	+0·376	−0·874	316
+4·32	+2·22	3629·26	+0·0483	+0·9135	+0·3967	...	...	...	...	317
+4·21	+2·21	3627·65	+0·0473	+0·9135	+0·3967	...	...	...	...	318
+4·14	+2·20	...	...	...	...	66 37·65	−0·004	+0·376	−0·874	319
+3·99	+2·20	...	...	...	...	235 34·72	−0·004	−0·475	+0·696	320
+3·96	+2·20	4091·34	−0·0449	−0·8216	−0·5653	...	...	...	...	321
+3·81	+2·19	4093·75	−0·0437	−0·8216	−0·5652	...	...	...	...	322
+3·74	+2·18	...	...	...	...	235 35·30	−0·003	−0·475	+0·695	323
+3·67	+2·18	...	...	...	...	235 35·41	−0·002	−0·474	+0·695	324
+3·64	+2·18	4095·97	−0·0422	−0·8217	−0·5651	...	...	...	...	325
+3·54	+2·17	4097·52	−0·0414	−0·8217	−0·5651	...	...	...	...	326
+3·42	+2·17	...	...	...	...	235 35·94	−0·001	−0·474	+0·695	327
+6·65	+2·43	...	...	...	...	281 2·08	+0·032	+0·169	+0·869	328
+6·60	+2·42	3902·44	−0·0599	−0·9768	+0·1913	...	...	...	...	329
+6·55	+2·41	3903·38	−0·0594	−0·9768	+0·1911	...	...	...	...	330
+6·44	+2·40	...	...	...	...	280 59·79	+0·032	+0·168	+0·868	331
+6·39	+2·40	...	...	...	...	280 59·26	+0·032	+0·168	+0·868	332
+6·37	+2·39	3906·61	−0·0577	−0·9770	+0·1905	...	...	...	...	333
+6·29	+2·38	3908·06	−0·0570	−0·9770	+0·1903	...	...	...	...	334
+6·19	+2·37	...	...	...	...	280 57·12	+0·031	+0·167	+0·868	335
+6·04	+2·36	...	...	...	...	76 20·86	−0·006	+0·170	−0·703	336
+5·99	+2·35	4772·72	+0·0634	+0·9670	+0·2360	...	...	...	...	337
+5·87	+2·33	4770·19	+0·0623	+0·9670	+0·2359	...	...	...	...	338
+5·77	+2·32	...	...	...	...	76 21·54	−0·007	+0·170	−0·704	339
+5·67	+2·31	...	...	...	...	76 21·78	−0·007	+0·170	−0·704	340
+5·57	+2·30	4765·01	+0·0593	+0·9670	+0·2357	...	...	...	...	341
+5·46	+2·29	4762·97	+0·0582	+0·9671	+0·2357	...	...	...	...	342
+5·32	+2·28	...	...	...	...	76 22·52	−0·007	+0·170	−0·705	343
−5·82	+2·32	...	...	...	...	279 34·18	+0·011	+0·141	+0·840	344
−5·88	+2·33	4057·67	+0·0616	−0·9813	+0·1661	...	...	...	...	345
−5·98	+2·34	4059·23	+0·0626	−0·9813	+0·1659	...	...	...	...	346
−6·19	+2·36	...	...	...	...	279 30·50	+0·011	+0·140	+0·839	347
−6·27	+2·37	...	...	...	...	279 30·26	+0·011	+0·140	+0·838	348
−6·31	+2·38	4064·84	+0·0658	−0·9815	+0·1650	...	...	...	...	349
−6·41	+2·39	4066·58	+0·0668	−0·9816	+0·1647	...	...	...	...	350
−6·48	+2·40	...	...	...	...	279 28·22	+0·011	+0·139	+0·838	351

No. of group — Date — Star of comparison	Rotation number	Time by chronometer	Local sidereal time	Greenwich sidereal time	Right ascension of star	Declination of star	Geocentric right ascension of planet	Geocentric declination of planet
		h. m. sec.	h. m. sec.	h. m. sec.	° ′ ″	° ′ ″	° ′ ″	° ′ ″
	352	6 38 16·5	6 39 1	2 48 11	42 6 30·93	−5 50 20·68	43 21 24·87	−5 32 49·54
	353	6 40 0·5	6 40 46	2 49 56	,,	,,	24·21	49·85
	354	6 44 11·5	6 44 57	2 54 7	,,	,,	22·62	50·55
LI.	355	6 57 47·5	6 58 33	3 7 43	,,	−5 50 20·69	17·46	52·87
Nov. 20, 1874, morning	356	6 59 40	7 0 25	3 9 35	,,	,,	16·76	53·18
ν	357	7 0 46	7 1 31	3 10 41	,,	,,	16·34	53·38
	358	7 5 4	7 5 49	3 14 59	,,	,,	14·72	54·11
	359	7 12 9	7 12 54	3 22 4	,,	,,	12·03	55·32
	360	23 20 23	23 21 17	19 30 27	44 28 32·57	−5 43 55·87	42 57 47·68	−5 42 24·45
	361	23 22 6	23 23 0	19 32 10	,,	,,	47·07	24·67
	362	23 26 5·5	23 27 0	19 36 10	,,	,,	45·68	25·18
LII.	363	23 29 3·5	23 29 58	19 39 8	,,	,,	44·65	25·55
Nov. 23, 1874, evening	364	23 30 22	23 31 16	19 40 26	,,	,,	44·19	25·71
ι	365	23 31 55	23 32 49	19 41 59	,,	,,	43·64	25·91
	366	23 35 33	23 36 27	19 45 37	,,	,,	42·37	26·37
	367	23 38 35	23 39 29	19 48 39	,,	,,	41·32	26·75
	368	23 42 30	23 43 24	19 52 34	41 45 3·43	−5 45 38·53	42 57 39·95	−5 42 27·25
	369	23 44 22	23 45 16	19 54 26	,,	,,	39·29	27·48
	370	23 48 4·5	23 48 59	19 58 9	,,	,,	38·00	27·95
LIII.	371	23 50 21	23 51 15	20 0 25	,,	,,	37·19	28·23
Nov. 23, 1874, evening	372	23 54 20	23 55 14	20 4 24	,,	,,	35·81	28·73
χ	373	23 56 3	23 56 57	20 6 7	,,	,,	35·20	28·94
	374	0 2 5	0 2 59	20 12 9	,,	,,	33·08	29·70
	375	0 6 31	0 7 25	20 16 35	,,	,,	31·53	30·26
	376	0 10 47	0 11 41	20 20 51	41 45 3·43	−5 45 38·53	42 57 30·04	−5 42 30·80
	377	0 12 37	0 13 31	20 22 41	,,	,,	29·42	31·04
	378	0 17 14	0 18 8	20 27 18	,,	,,	27·78	31·60
LIV.	379	0 19 44	0 20 38	20 29 48	,,	,,	26·92	31·82
Nov. 23, 1874, evening	380	0 26 0	0 26 54	20 36 4	,,	,,	24·77	32·71
χ	381	0 27 18	0 28 12	20 37 22	,,	,,	24·27	32·87
	382	0 34 2	0 34 56	20 44 6	,,	,,	21·93	33·70
	383	0 36 57	0 37 51	20 47 1	,,	,,	20·89	34·07
	384	0 44 18	0 45 12	20 54 22	44 28 32·57	−5 43 55·87	42 57 18·35	−5 42 35·00
	385	0 45 35	0 46 29	20 55 39	,,	,,	17·89	35·16
	386	0 50 31	0 51 25	21 0 35	,,	,,	16·16	35·76
LV.	387	0 53 1	0 53 55	21 3 5	,,	,,	15·30	36·08
Nov. 23, 1874, evening	388	0 55 35	0 56 29	21 5 39	,,	,,	14·39	36·40
ι	389	0 56 46	0 57 40	21 6 50	,,	,,	13·97	36·55
	390	0 59 45	1 0 39	21 9 49	,,	,,	12·93	36·93
	391	1 2 37	1 3 31	21 12 41	,,	,,	11·94	37·30

Parallax in AR	Parallax in Dec.	Distances				Position Angles				Rotation number
		Tabular distance	Par. factor in distance	Factor for change of AR	Factor for change of Dec.	Tabular position angle	Par. factor in pos. angle	Factor for change of AR	Factor for change of Dec.	
−6″.59	+2″.41	″	*f‴*	*f′*	*f″*	° ′	*f‴*	*f′*	*f″*	
−6·61	+2·42	4587·09	−0·0584	+0·9685	+0·2296	76 43·48	−0·029	+0·172	−0·733	352
−6·70	+2·43	4585·31	−0·0593	+0·9685	+0·2296	...	...	...	...	353
−6·93	+2·46	...	...	...	...	...	...	...	...	354
−6·96	+2·47	...	...	...	...	76 44·54	−0·030	+0·172	−0·734	355
−6·98	+2·48	4578·31	−0·0619	+0·9686	+0·2293	76 44·63	−0·030	+0·172	−0·734	356
−7·05	+2·49	4576·51	−0·0626	+0·9686	+0·2292	...	...	...	...	357
−7·16	+2·50	...	...	...	...	...	...	...	...	358
						76 45·34	−0·031	+0·172	−0·735	359
+6·31	+2·35	...	...	...	...	270 59·56	+0·016	+0·011	+0·638	360
+6·28	+2·35	5412·95	−0·0621	−0·9949	+0·0173	...	...	...	...	361
+6·23	+2·34	5414·37	−0·0616	−0·9949	+0·0172	...	...	...	...	362
+6·20	+2·33	...	...	...	...	270 58·81	+0·016	+0·011	+0·638	363
+6·18	+2·32	...	...	...	...	270 58·71	+0·016	+0·011	+0·638	364
+6·13	+2·32	5416·49	−0·0606	−0·9949	+0·0170	...	...	...	...	365
+5·97	+2·31	5417·91	−0·0590	−0·9949	+0·0169	...	...	...	...	366
+5·83	+2·29	...	...	...	...	270 57·99	+0·015	+0·011	+0·637	367
+5·74	+2·28	...	...	...	...	87 26·81	−0·016	+0·035	−0·794	368
+5·70	+2·27	4344·04	+0·0577	+0·9940	+0·0445	...	...	...	...	369
+5·61	+2·27	4342·65	+0·0568	+0·9940	+0·0444	...	...	...	...	370
+5·56	+2·27	...	...	...	...	87 27·47	−0·016	+0·035	−0·795	371
+5·46	+2·26	...	...	...	...	87 27·83	−0·016	+0·035	−0·795	372
+5·41	+2·25	4339·62	+0·0548	+0·9940	+0·0442	...	...	...	...	373
+5·27	+2·24	4337·34	+0·0534	+0·9940	+0·0441	...	...	...	...	374
+5·15	+2·23	...	...	...	...	87 28·91	−0·016	+0·035	−0·796	375
+5·05	+2·22	...	...	...	...	87 29·29	−0·016	+0·035	−0·796	376
+4·99	+2·21	4333·36	+0·0506	+0·9940	+0·0438	...	...	...	...	377
+4·87	+2·20	4331·59	+0·0494	+0·9941	+0·0437	...	...	...	...	378
+4·80	+2·19	...	...	...	...	87 29·97	−0·016	+0·035	−0·797	379
+4·63	+2·18	...	...	...	...	87 30·64	−0·016	+0·035	−0·798	380
+4·59	+2·18	4327·76	+0·0465	+0·9941	+0·0434	...	...	...	...	381
+4·38	+2·17	4325·19	+0·0444	+0·9941	+0·0432	...	...	...	...	382
+4·32	+2·16	...	...	...	...	87 31·59	−0·016	+0·034	−0·798	383
+4·11	+2·15	...	...	...	...	270 52·43	+0·014	+0·010	+0·635	384
+4·07	+2·15	5443·99	−0·0402	−0·9949	+0·0152	...	...	...	...	385
+3·92	+2·14	5445·85	−0·0387	−0·9949	+0·0152	...	...	...	...	386
+3·84	+2·13	...	...	...	...	270 51·63	+0·014	+0·010	+0·634	387
+3·78	+2·13	...	...	...	...	270 51·49	+0·014	+0·010	+0·634	388
+3·75	+2·13	5448·19	−0·0370	−0·9949	+0·150	...	...	...	...	389
+3·66	+2·12	5449·32	−0·0359	−0·9949	+0·149	...	...	...	...	390
+3·56	+2·12	...	...	...	...	270 50·89	+0·014	+0·009	+0·634	391

No. of group — Date — Star of comparison	Rotation number	Time by chronometer	Local sidereal time	Greenwich sidereal time	Right ascension of star	Declination of star	Geocentric right ascension of planet	Geocentric declination of planet
		h. m. sec.	h. m. sec.	h. m. sec.	° ′ ″	° ′ ″	° ′ ″	° ′ ″
	384	5 38 35	5 39 33	1 48 43	44 28 32·65	−5 43 56·02	42 47 25·31	−5 45 54·49
	385	5 43 23	5 44 21	1 53 31	,,	,,	23·70	54·99
LVI.	386	5 48 5	5 49 3	1 58 13	,,	,,	22·14	55·49
Nov. 24, 1874, morning	387	5 52 48	5 53 46	2 2 56	,,	,,	20·55	55·98
ι	388	5 54 34	5 55 32	2 4 42	,,	,,	19·97	56·17
	389	5 58 57·5	5 59 56	2 9 6	,,	,,	18·48	56·64
	390	6 12 20	6 13 18	2 22 28	,,	,,	14·02	58·03
	391	6 15 15	6 16 13	2 25 23	41 45 3·49	−5 45 38·67	42 47 13·04	−5 45 58·33
	392	6 18 55	6 19 53	2 29 3	,,	,,	11·82	45 58·71
LVII.	393	6 38 47	6 39 45	2 48 55	,,	,,	5·19	46 0·80
Nov. 24, 1874, morning	394	6 42 17	6 43 15	2 52 25	,,	,,	4·01	1·17
χ	395	6 44 18	6 45 16	2 54 26	,,	,,	3·35	1·38
	396	6 53 25	6 54 23	3 3 33	,,	−5 45 38·68	47 0·30	2·32
	397	6 55 50	6 56 48	3 5 58	,,	,,	46 59·52	2·57
	398	7 0 15	7 1 13	3 10 23	41 45 3·49	−5 45 38·68	42 46 58·01	−5 46 3·03
	399	7 2 8	7 3 6	3 12 16	,,	,,	57·38	3·23
LVIII.	400	7 5 13	7 6 11	3 15 21	,,	,,	56·35	3·55
Nov. 24, 1874, morning	401	7 9 23·5	7 10 22	3 19 32	,,	,,	54·98	3·98
χ	402	7 10 36·5	7 11 35	3 20 45	,,	,,	54·58	4·10
	403	7 13 43	7 14 41	3 23 51	,,	,,	53·53	4·43
	404	7 16 5	7 17 3	3 26 13	,,	,,	52·74	4·68
	405	7 18 53	7 19 51	3 29 1	44 28 32·65	−5 43 56·03	42 46 51·80	−5 46 4·97
	406	7 20 55	7 21 53	3 31 3	,,	,,	51·13	5·18
LIX.	407	7 24 27·5	7 25 26	3 34 36	,,	,,	49·96	5·55
Nov. 24, 1874, morning	408	7 28 1	7 28 59	3 38 9	,,	,,	48·78	5·92
ι	409	7 29 28	7 30 26	3 39 36	,,	,,	48·29	6·07
	405*	23 24 0	23 25 1	19 34 11	42 37 14·49	−5 51 23·50	42 41 33·89	−5 47 40·07
	406*	23 26 36	23 27 37	19 36 47	,,	,,	33·05	40·31
LX.	407*	23 34 22	23 35 23	19 44 33	,,	,,	30·53	41·03
Nov. 25, 1874, evening	408*	23 37 36·5	23 38 38	19 47 48	,,	,,	29·46	41·35
μ	409*	23 38 58	23 39 59	19 49 9	,,	,,	29·02	41·47
	410	23 40 42	23 41 43	19 50 53	,,	,,	28·46	41·63
	411	23 43 58	23 44 59	19 54 9	,,	,,	27·41	41·93
	412	23 49 6	23 50 7	19 59 17	,,	,,	25·74	42·41
	413	23 53 20	23 54 21	20 3 31	42 37 14·49	−5 51 23·50	42 41 24·36	−5 47 42·80
	414	23 54 51	23 55 52	20 5 2	,,	,,	23·87	42·94
LXI.	415	23 57 29	23 58 30	20 7 40	,,	,,	23·02	43·18
Nov. 25, 1874, evening	416	0 1 45	0 2 46	20 11 56	,,	,,	21·63	43·58
μ	417	0 4 35	0 5 36	20 14 46	,,	,,	20·72	43·84
	418	0 6 31	0 7 32	20 16 42	,,	,,	20·09	44·01
	419	0 10 1	0 11 2	20 20 12	,,	,,	18·94	44·35
	420	0 13 1	0 14 2	20 23 12	,,	,,	17·98	44·63

Parallax in α	Parallax in Dec.	Distances				Position Angles				Rotation number
		Tabular distance	Par. factor in distance	Factor for change of α	Factor for change of Dec.	Tabular position angle	Par. factor in pos. angle	Factor for change of α	Factor for change of Dec.	
		"	f'''	f'	f''	° ′	f'''	f'	f''	
−5·22	+2·22	...	..	...	...	268 53·87	+0·013	−0·011	+0·572	384
−5·34	+2·23	6044·87	+0·0527	−0·9948	−0·0193	...	...	...	...	385
−5·46	+2·24	6046·55	+0·0539	−0·9948	−0·0194	...	...	...	...	386
−5·57	+2·25	...	...	...	...	268 53·10	+0·013	−0·011	+0·571	387
−5·62	+2·26	6048·88	+0·0555	−0·9948	−0·0195	...	...	...	...	388
−5·72	+2·27	6050·47	+0·0565	−0·9948	−0·0196	...	...	...	...	389
−6·02	+2·30	...	...	...	...	268 52·04	+0·014	−0·011	+0·570	390
−6·09	+2·31	...	...	...	...	90 16·10	−0·021	−0·004	−0·933	391
−6·16	+2·32	3703·40	−0·0614	+0·9950	−0·0048	...	...	...	...	392
−6·55	+2·37	3696·41	−0·0653	+0·9950	−0·0053	...	...	...	...	393
−6·62	+2·38	...	...	...	...	90 18·72	−0·022	−0·005	−0·935	394
−6·65	+2·39	3694·49	−0·0663	+0·9950	−0·0055	...	...	...	...	395
−6·80	+2·41	3691·32	−0·0678	+0·9950	−0·0058	...	...	...	...	396
−6·84	+2·42	...	...	...	...	90 20·00	−0·022	−0·005	−0·936	397
−6·91	+2·43	...	...	...	...	90 20·43	−0·022	−0·006	−0·937	398
−6·94	+2·44	3688·28	−0·0692	+0·9950	−0·0060	...	...	...	...	399
−6·99	+2·45	3687·20	−0·0696	+0·9949	−0·0061	...	...	...	...	400
−7·05	+2·46	...	...	...	...	90 21·30	−0·023	−0·006	−0·937	401
−7·07	+2·46	3685·36	−0·0704	+0·9949	−0·0062	...	...	...	...	402
−7·12	+2·47	3684·27	−0·0709	+0·9949	−0·0063	...	...	...	...	403
−7·15	+2·47	...	...	...	...	90 21·96	−0·023	−0·006	−0·938	404
−7·20	+2·46	...	...	...	...	268 48·47	+0·015	−0·012	+0·568	405
−7·22	+2·47	6079·32	+0·0714	−0·9948	−0·0208	...	...	...	...	406
−7·26	+2·51	6080·53	+0·0718	−0·9948	−0·0209	...	...	...	...	407
−7·30	+2·55	...	...	...	...	268 48·02	+0·015	−0·012	+0·568	408
−7·31	+2·56	6082·26	+0·0722	−0·9948	−0·0210	...	...	...	...	409
+6·08	+2·30	...	...	...	...	49 28·81	+0·217	+6·429	−7·561	405*
+6·03	+2·29	346·59	+0·0605	+0·7555	+0·6506	...	...	...	...	406*
+5·85	+2·28	344·08	+0·0590	+0·7533	+0·6532	...	...	...	...	407*
+5·78	+2·28	...	...	...	...	49 8·06	+0·205	+6·558	−7·619	408*
+5·75	+2·27	...	...	...	...	49 5·98	+0·205	+6·570	−7·624	409*
+5·72	+2·26	342·02	+0·0578	+0·7515	+0·6553	...	...	...	...	410
+5·63	+2·25	340·96	+0·0570	+0·7505	+0·6564	...	...	...	...	411
+5·54	+2·24	...	...	...	...	48 50·38	+0·198	+6·668	−7·667	412
+5·41	+2·23	...	...	...	...	48 43·38	+0·192	+6·711	−7·685	413
+5·38	+2·23	337·45	+0·0549	+0·7470	+0·6604	...	...	...	...	414
+5·32	+2·22	336·60	+0·0544	+0·7464	+0·6611	...	...	...	...	415
+5·21	+2·21	...	...	...	...	48 29·83	+0·183	+6·796	−7·720	416
+5·13	+2·20	...	...	...	...	48 25·19	+0·180	+6·825	−7·733	417
+5·08	+2·20	333·68	+0·0524	+0·7435	+0·6644	...	...	...	...	418
+4·98	+2·19	332·51	+0·0516	+0·7424	+0·6657	...	...	...	...	419
+4·91	+2·18	...	...	...	...	48 11·21	+0·170	+6·913	−7·768	420

No. of group — Date — Star of comparison	Rotation number	Time by chronometer	Local sidereal time	Greenwich sidereal time	Right ascension of star	Declination of star	Geocentric right ascension of planet	Geocentric declination of planet
		h. m. sec.	h. m. sec.	h. m. sec.	° ′ ″	° ′ ″	° ′ ″	° ′ ″
	421	0 17 12	0 18 13	20 27 23	42 37 14·49	−5 51 23·50	42 41 16·61	−5 47 45·01
	422	0 18 42	0 19 43	20 28 53	,,	,,	16·13	45·15
LXII.	423	0 23 39·5	0 24 41	20 33 51	,,	,,	14·50	45·62
Nov. 25, 1874, evening	424	0 26 13	0 27 14	20 36 24	,,	,,	13·69	45·84
μ	425	0 27 19	0 28 20	20 37 30	,,	,,	13·33	45·95
	426	0 28 38	0 29 39	20 38 49	,,	,,	12·90	46·08
	427	0 31 9·5	0 32 11	20 41 21	,,	,,	12·08	46·30
	428	0 34 35	0 35 36	20 44 46	,,	,,	10·98	46·61
	429	0 39 20	0 40 21	20 49 31	42 37 14·49	−5 51 23·50	42 41 9·44	−5 47 47·05
	430	0 42 11	0 43 12	20 52 22	,,	,,	8·51	47·32
LXIII.	431	0 45 16	0 46 17	20 55 27	,,	,,	7·52	47·61
Nov. 25, 1874, evening	432	0 47 46	0 48 47	20 57 57	,,	,,	6·71	47·83
μ	433	0 49 41·5	0 50 43	20 59 53	,,	,,	6·08	48·01
	434	0 50 30	0 51 31	21 0 41	,,	,,	5·82	48·08
	435	0 53 39	0 54 40	21 3 50	,,	,,	4·79	48·38
	436	0 55 50	0 56 51	21 6 1	,,	,,	4·10	48·57
	437	5 47 26·5	5 48 29	1 57 39	42 37 14·50	−5 51 23·53	42 39 29·91	−5 48 14·44
	438	5 49 10	5 50 12	1 59 22	,,	,,	29·34	15·11
LXIV.	439	5 52 46	5 53 48	2 2 58	,,	,,	28·19	15·43
Nov. 25, 1874, morning	440	5 55 45	5 56 47	2 5 57	,,	,,	27·22	15·70
μ	441	5 57 35	5 58 37	2 7 47	,,	,,	26·64	15·84
	442	5 59 15·5	6 0 18	2 9 28	,,	,,	26·09	16·00
	443	6 2 33	6 3 35	2 12 45	,,	,,	25·05	16·28
	444	6 5 55	6 6 57	2 16 7	,,	,,	23·96	16·59
	445	6 8 41	6 9 43	2 18 53	42 37 14·50	−5 51 23·53	42 39 23·07	−5 48 16·83
	446	6 11 5	6 12 7	2 21 17	,,	,,	22·30	17·04
LXV.	447	6 14 56	6 15 58	2 25 8	,,	,,	21·05	17·39
Nov. 25, 1874, morning	448	6 17 41·5	6 18 44	2 27 54	,,	,,	20·18	17·62
μ	449	6 18 56·5	6 19 59	2 29 9	,,	,,	19·76	17·73
	450	6 20 33	6 21 35	2 30 45	,,	,,	19·26	17·88
	451	6 24 7	6 25 9	2 34 19	,,	,,	18·11	18·19
	452	6 33 8	6 34 10	2 43 20	42 37 14·50	−5 51 23·53	42 39 15·22	−5 48 18·98
	453	6 36 26	6 37 28	2 46 38	,,	,,	14·15	19·28
	454	6 39 15	6 40 17	2 49 27	,,	,,	13·25	19·52
LXVI.	455	6 42 52	6 43 54	2 53 4	,,	,,	12·09	19·83
Nov. 25, 1874, morning	455 bis	6 45 34	6 46 36	2 55 46	,,	,,	11·21	20·08
μ	456	6 46 57	6 47 59	2 57 9	,,	,,	10·76	20·21
	457	6 50 29	6 51 31	3 0 41	,,	,,	9·64	20·51
	458	7 0 1	7 1 3	3 10 13	,,	,,	6·56	21·35

Parallax in AR	Parallax in Dec.	Distances				Position Angles				Rotation number
		Tabular distance	Par. factor in distance	Factor for change of AR	Factor for change of Dec.	Tabular position angle	Par. factor in pos. angle	Factor for change of AR	Factor for change of Dec.	
+4"81	+2"17	"	*f'''*	*f'*	*f''*	48° 4'09	*f'''* +0·166	*f'* +6·957	*f''* −7·785	421
+4·75	+2·17	329·71	+0·0496	+0·7396	+0·6688	...	...	...	...	422
+4·63	+2·16	328·10	+0·0487	+0·7379	+0·6707	...	...	...	...	423
+4·58	+2·16	...	...	...	...	47 48·66	+0·154	+7·054	−7·822	424
+4·55	+2·15	...	...	...	...	47 46·85	+0·153	+7·067	−7·833	425
+4·52	+2·15	326·52	+0·0477	+0·7363	+0·6725	...	...	...	...	426
+4·43	+2·14	325·70	+0·0470	+0·7354	+0·6734	...	...	...	...	427
+4·32	+2·14	...	...	...	...	47 33·84	+0·141	+7·147	−7·857	428
+4·18	+2·13	...	...	...	...	47 25·37	+0·133	+7·200	−7·877	429
+4·09	+2·13	322·14	+0·0443	+0·7316	+0·6777	...	...	...	...	430
+4·02	+2·12	321·16	+0·0438	+0·7305	+0·6788	...	...	...	...	431
+3·95	+2·12	...	...	...	...	47 10·24	+0·121	+7·295	−7·910	432
+3·89	+2·11	...	...	...	...	47 6·72	+0·118	+7·318	−7·919	433
+3·87	+2·11	319·48	+0·0425	+0·7286	+0·6809	...	...	...	...	434
+3·77	+2·10	318·45	+0·0417	+0·7275	+0·6821	...	...	...	...	435
+3·71	+2·10	...	...	...	...	46 55·41	+0·107	+7·389	−7·943	436
−5·44	+2·22	...	...	...	...	34 3·18	−0·857	+12·335	−8·380	437
−5·47	+2·22	230·02	−0·0120	+0·5566	+0·8288	...	...	...	...	438
−5·54	+2·23	229·08	−0·0122	+0·5536	+0·8308	...	...	...	...	439
−5·61	+2·24	...	...	...	...	33 38·14	−0·891	+12·538	−8·385	440
−5·68	+2·24	...	...	...	...	33 31·18	−0·902	+12·581	−8·377	441
−5·72	+2·25	227·37	−0·0125	+0·5479	+0·8347	...	...	...	...	442
−5·79	+2·26	226·54	−0·0127	+0·5450	+0·8365	...	...	...	...	443
−5·87	+2·27	...	...	...	...	33 0·97	−0·939	+12·775	−8·345	444
−5·93	+2·27	...	...	...	...	32 50·86	−0·951	+12·840	−8·333	445
−5·98	+2·28	224·32	−0·0129	+0·5375	+0·8415	...	...	...	...	446
−6·06	+2·29	223·32	−0·0131	+0·5340	+0·8437	...	...	...	...	447
−6·12	+2·29	...	...	...	...	32 17·56	−0·983	+13·053	−8·292	448
−6·14	+2·30	...	...	...	...	32 12·93	−0·994	+13·082	−8·286	449
−6·17	+2·31	221·92	−0·0130	+0·5289	+0·8470	...	...	...	...	450
−6·25	+2·32	221·01	−0·0131	+0·5255	+0·8491	...	...	...	...	451
−6·43	+2·35	...	...	...	...	31 18·83	−1·056	+13·425	−8·210	452
−6·49	+2·35	217·93	−0·0132	+0·5139	+0·8562	...	...	...	...	453
−6·54	+2·36	217·24	−0·0132	+0·5112	+0·8579	...	...	...	...	454
−6·61	+2·37	...	...	...	...	30 40·98	−1·096	+13·665	−8·150	455
−6·65	+2·38	...	...	...	...	30 30·39	−1·107	+13·732	−8·133	455 bis
−6·68	+2·38	215·33	−0·0131	+0·5036	+0·8624	...	...	...	...	456
−6·74	+2·39	214·49	−0·0131	+0·5002	+0·8644	...	...	...	...	457
−6·88	+2·41	...	...	...	...	29 32·82	−1·163	+14·095	−8·031	458

No. of group — Date — Star of comparison	Rotation number	Time by chronometer	Local sidereal time	Greenwich sidereal time	Right ascension of star	Declination of star	Geocentric right ascension of planet	Geocentric declination of planet
		h. m. sec.	h. m. sec.	h. m. sec.	° ′ ″	° ′ ″	° ′ ″	° ′ ″
	459	7 9 34·5	7 10 37	3 19 47	42 37 14·50	−5 51 23·53	42 39 3·51	−5 48 22·19
LXVII.	460	7 10 45	7 11 47	3 20 57	,,	−5 51 23·54	3·12	22·22
Nov. 25, 1874, morning	461	7 13 50	7 14 52	3 24 2	,,	,,	2·14	22·56
μ	462	7 17 25	7 18 27	3 27 37	,,	,,	39 1·01	22·89
	463	7 21 21	7 22 23	3 31 33	,,	,,	38 59·71	23·23
	464	23 28 41	23 29 45	19 38 55	42 37 14·53	−5 51 23·62	42 33 53·75	−5 49 42·79
	465	23 30 6·5	23 31 11	19 40 21	,,	,,	53·29	42·90
	466	23 33 1	23 34 5	19 43 15	,,	,,	52·39	43·13
LXVIII.	467	23 35 33	23 36 37	19 45 47	,,	,,	51·60	43·32
Nov. 26, 1874, evening	468	23 37 23	23 38 27	19 47 37	,,	,,	51·03	43·47
μ	469	23 38 30	23 39 34	19 48 44	,,	,,	50·69	43·55
	470	23 40 40	23 41 44	19 50 54	,,	,,	50·01	43·72
	471	23 43 30	23 44 34	19 53 44	,,	,,	49·13	43·93
	472	23 46 7	23 47 11	19 56 21	42 37 14·53	−5 51 23·62	42 33 48·30	−5 49 44·13
	473	23 47 21	23 48 25	19 57 35	,,	,,	47·93	44·23
	474	23 50 6	23 51 10	20 0 20	,,	,,	47·07	44·43
LXIX.	475	23 52 31	23 53 35	20 2 45	,,	,,	46·32	44·63
Nov. 26, 1874, evening	476	23 54 5·5	23 55 10	20 4 20	,,	,,	45·83	44·75
μ	477	23 55 18	23 56 22	20 5 32	,,	,,	45·45	44·84
	478	23 57 54	23 58 58	20 8 8	,,	,,	44·64	45·05·
	479	0 1 20	0 2 24	20 11 34	,,	,,	43·57	45·29
	480	0 3 50	0 4 54	20 14 4	42 37 14·53	−5 51 23·62	42 33 42·80	−5 49 45·48
	481	0 5 25	0 6 29	20 15 39	,,	,,	42·31	45·57
	482	0 7 31	0 8 35	20 17 45	,,	,,	41·65	45·77
LXX.	483	0 11 2	0 12 6	20 21 16	,,	,,	40·55	46·04
Nov. 26, 1874, evening	484	0 14 50	0 15 54	20 25 4	42 37 14·54	,,	39·37	46·33
μ	485	0 16 2	0 17 6	20 26 16	,,	,,	38·99	46·42
	486	0 18 12	0 19 16	20 28 26	,,	,,	38·33	46·59
	487	0 41 31	0 42 35	20 51 45	,,	,,	31·07	48·35
	488	5 51 35	5 52 40	2 1 50	42 37 14·55	−5 51 23·65	43 31 55·06	−5 50 11·35
	489	5 53 32	5 54 37	2 3 47	,,	,,	54·47	11·51
	490	5 57 0	5 58 5	2 7 15	,,	,,	53·39	11·75
LXXI.	491	6 0 9	6 1 14	2 10 24	,,	,,	52·42	11·97
Nov. 26, 1874, morning	492	6 2 46	6 3 51	2 13 1	,,	,,	51·62	12·17
μ	493	6 4 56	6 6 1	2 15 11	,,	,,	50·95	12·32
	494	6 9 59	6 11 4	2 20 14	,,	,,	49·40	12·68
	495	6 13 10	6 14 15	2 23 25	,,	,,	48·43	12·91
	496	6 40 37	6 41 42	2 50 52	42 37 14·55	−5 51 23·65	42 31 39·97	−5 50 14·89
	497	6 42 37	6 43 42	2 52 52	,,	,,	39·36	15·04
LXXII.	498	6 45 6·5	6 46 12	2 55 22	,,	,,	38·58	15·21
Nov. 26, 1874, morning	499	6 48 33	6 49 38	2 58 48	,,	,,	37·53	15·47
μ	500	6 53 38	6 54 43	3 3 53	,,	,,	35·97	15·83
	501	6 56 20	6 7 25	3 6 35	,,	,,	35·12	16·03
	502	6 59 7	7 0 12	3 9 22	,,	,,	34·28	16·22

Parallax in AR	Parallax in Dec.	Distances				Position Angles				Rotation number
		Tabular distance	Par. factor in distance	Factor for change of AR	Factor for change of Dec.	Tabular position angle	Par. factor in pos. angle	Factor for change of AR	Factor for change of Dec.	
		"	*f'''*	*f'*	*f''*	° ′	*f'''*	*f'*	*f''*	
−7".01	+2".44	...	...	...	...	28 54·29	−1·199	+14·336	− 7·957	459
−7·05	+2·46	209·73	−0·0122	+0·4793	+0·8763	...	...	...	...	460
−7·09	+2·47	208·95	−0·0121	+0·4762	+0·8780	...	...	...	...	461
−7·14	+2·49	...	...	...	...	28 21·56	−1·234	+14·536	− 7·887	462
−7·20	+2·51	...	...	...	...	28 4·33	−1·251	+14·640	− 7·849	463
+5·94	+2·27	...	...	...	...	298 0·55	+0·752	+ 7·354	+13·897	464
+5·91	+2·27	219·92	−0·0413	−0·8790	+0·4683	...	...	...	...	465
+5·85	+2·26	220·65	−0·0410	−0·8804	+0·4657	...	...	...	...	466
+5·80	+2·25	...	...	...	...	297 36·39	+0·729	+ 7·199	+13·837	467
+5·75	+2·25	...	...	...	...	297 29·90	+0·723	+ 7·157	+13·822	468
+5·72	+2·25	222·07	−0·0401	−0·8829	+0·4608	...	...	...	...	469
+5·67	+2·24	222·63	−0·0398	−0·8839	+0·4588	...	...	...	...	470
+5·60	+2·24	...	...	...	...	297 8·99	+0·702	+ 7·023	+13·766	471
+5·55	+2·23	...	...	...	...	296 59·99	+0·693	+ 6·966	+13·742	472
+5·52	+2·23	224·37	−0·0389	−0·8869	+0·4529	...	...	...	...	473
+5·45	+2·23	225·10	−0·0384	−0·8881	+0·4506	...	...	...	...	474
+5·39	+2·22	...	...	...	...	296 38·35	+0·672	+ 6·829	+13·685	475
+5·35	+2·21	...	...	...	...	296 32·99	+0·666	+ 6·795	+13·669	476
+5·33	+2·21	226·46	−0·0375	−0·8904	+0·4460	...	...	...	...	477
+5·26	+2·20	227·14	−0·0371	−0·8915	+0·4436	...	...	...	...	478
+5·18	+2·19	...	...	...	...	296 9 16	+0·642	+ 6·644	+13·602	479
+5·10	+2·19	...	...	...	...	296 0·99	+0·633	+ 6·592	+13·577	480
+5·07	+2·18	229·15	−0·0359	−0·8946	+0·4373	...	...	...	...	481
+5·02	+2·18	229·70	−0·0344	−0·8955	+0·4355	...	...	...	...	482
+4·94	+2·17	...	...	...	...	295 37·55	+0·612	+ 6·446	+13·509	483
+4·85	+2·16	...	...	...	...	295 25·36	+0·600	+ 6·371	+13·473	484
+4·83	+2·15	231·98	−0·0342	−0·8989	+0·4283	...	...	...	...	485
+4·74	+2·14	232·57	−0·0336	−0·8998	+0·4264	...	...	...	...	486
+4·09	+2·11	...	...	...	...	294 2·80	+0·518	+ 5·862	+13·205	487
−5·53	+2·23	...	...	...	...	282 58·82	+0·098	+2·327	+10·149	488
−5·58	+2·23	332·39	+0·0591	−0·9696	+0·2237	...	...	...	...	489
−5·67	+2·24	333·48	+0·0600	−0·9699	+0·2223	...	...	...	...	490
−5·73	+2·25	...	...	...	...	282 46·29	+0·096	+ 2·272	+10·078	491
−5·81	+2·25	...	...	...	...	282 42·31	+0·095	+ 2·255	+10·056	492
−5·85	+2·26	335·90	+0·0616	−0·9706	+0·2191	...	...	...	...	493
−5·94	+2·27	337·41	+0·0626	−0·9711	+0·2171	...	...	...	...	494
−6·00	+2·28	...	...	...	...	282 27·76	+0·096	+ 2·193	+ 9·973	495
−6·55	+2·35	...	...	...	...	281 50·09	+0·096	+ 2·034	+ 9·755	496
−6·58	+2·36	347·32	+0·0689	−0·9738	+0·2043	...	...	...	...	497
−6·63	+2·37	348·10	+0·0694	−0·9740	+0·2034	...	...	...	...	498
−6·69	+2·38	...	...	...	...	281 39·60	+0·097	+ 1·990	+ 9·681	499
−6·77	+2·39	350·65	+0·0708	−0·9747	+0·2002	...	...	...	...	500
−6·82	+2·40	351·49	+0·0713	−0·9749	+0·1992	...	...	...	...	501
−6·86	+2·41	...	...	...	...	281 26·01	+0·099	+ 1·934	+ 9·614	502

No. of group — Date — Star of comparison	Rotation number	Time by chronometer	Local sidereal time	Greenwich sidereal time	Right ascension of star	Declination of star	Geocentric right ascension of planet	Geocentric declination of planet
		h. m. sec.	h. m. sec.	h. m. sec.	° ′ ″	° ′ ″	° ′ ″	° ′ ″
	503	7 1 47	7 2 52	3 12 2	42 37 14·55	−5 51 23·65	42 31 33·45	−5 50 16·41
	504	7 2 59	7 4 4	3 13 14	,,	,,	33·10	16·49
	505	7 6 33·5	7 7 39	3 16 49	,,	,,	31·98	16·75
LXXIII.	506	7 8 52	7 9 57	3 19 7	,,	,,	31·29	16·92
Nov. 26, 1874, morning	506 bis	7 9 45	7 10 50	3 20 0	,,	,,	31·01	16·98
μ	507	7 11 44	7 12 49	3 21 59	,,	,,	30·39	17·12
	508	7 14 7	7 15 12	3 24 22	,,	−5 51 23·66	29·67	17·29
	509	7 18 2	7 19 7	3 28 17	,,	,,	28·48	17·58
	510	7 19 50	7 20 55	3 30 5	42 37 14·55	−5 51 23·66	42 31 27·91	−5 50 17·71
LXXIV.	511	7 22 45	7 23 50	3 33 0	,,	,,	27·02	17·92
Nov. 26, 1874, morning	512	7 26 35	7 27 40	3 36 50	,,	,,	25·83	18·19
μ	513	7 29 24	7 30 29	3 39 39	,,	,,	24·97	18·40
	510	23 27 49	23 28 57	19 38 7	42 37 14·58	−5 51 23·74	42 26 35·02	−5 51 21·56
	511	23 44 29	23 45 37	19 54 47	,,	,,	30·06	22·58
	512	23 47 0	23 48 8	19 57 18	,,	,,	29·29	22·73
LXXV.	513	23 49 44	23 50 52	20 0 2	,,	,,	28·48	22·89
Nov. 27, 1874, evening	514	23 51 54	23 53 2	20 2 12	,,	,,	27·83	23·02
μ	515	23 53 0	23 54 8	20 3 18	,,	,,	27·51	23·10
	516	23 56 30	23 57 38	20 6 48	,,	,,	26·46	23·30
	517	23 59 35	0 0 43	20 9 53	,,	,,	25·55	23·49
	518	6 31 1	6 32 35	2 41 45	42 37 14·62	−5 51 23·89	42 17 37·18	−5 52 54·86
	519	6 32 12	6 33 46	2 42 56	,,	,,	36·85	54·91
	520	6 35 27	6 37 1	2 46 11	,,	,,	35·93	55·03
LXXVI.	521	6 38 21	6 39 55	2 49 5	,,	,,	35·13	55·14
Nov. 28, 1874, morning	522	6 40 10	6 41 44	2 50 54	,,	,,	34·61	55·21
μ	523	6 43 13	6 44 47	2 53 57	,,	,,	33·78	55·34
	524	6 53 40	6 55 14	3 4 24	,,	,,	30·86	55·75
	525	6 57 52	6 59 26	3 8 36	,,	,,	29·64	55·93
	526	5 57 38	5 59 15	2 8 25	42 6 31·35	−5 50 21·74	42 11 14·78	−5 53 39·58
	527	5 59 56	6 1 33	2 10 43	,,	,,	14·18	39·63
	528	6 3 20	6 4 57	2 14 7	,,	,,	13·27	39·73
LXXVII.	529	6 5 20	6 6 57	2 16 7	,,	,,	12·74	39·76
Nov. 29, 1874, morning	530	6 6 44	6 8 21	2 17 31	,,	,,	12·37	39·80
ν	531	6 8 43	6 10 10	2 19 20	,,	,,	11·89	39·85
	532	6 12 9	6 13 46	2 22 56	,,	,,	10·95	39·93
	533	6 20 35	6 22 12	2 31 22	,,	,,	8·71	40·12
	534	6 23 37·5	6 25 15	2 34 25	42 6 31·35	−5 50 21·74	42 11 7·91	−5 53 40·20
	535	6 25 42	6 27 19	2 36 29	,,	,,	7·36	40·25
	536	6 29 23	6 31 0	2 40 10	,,	,,	6·40	40·33
LXXVIII.	537	6 32 54	6 34 31	2 43 41	,,	,,	5·48	40·42
Nov. 29, 1874, morning	538	6 34 47	6 36 24	2 45 34	,,	,,	4·97	40·46
ν	539	6 36 46	6 38 23	2 47 33	,,	,,	4·44	40·51
	540	6 39 41·5	6 41 19	2 50 29	,,	,,	3·67	40·58
	541	6 43 34·5	6 45 12	2 54 22	,,	,,	2·64	40·68

Parallax in AR	Parallax in Dec.	Distances				Position Angles				Rotation number
		Tabular distance	Par. factor in distance	Factor for change of AR	Factor for change of Dec.	Tabular position angle	Par. factor in pos. angle	Factor for change of AR	Factor for change of Dec.	
		"	*f'''*	*f'*	*f''*	° ′	*f'''*	*f'*	*f''*	
−6".90	+2".42	...	...	...	...	281 22.63	+0.100	+1.921	+9.594	503
−6.92	+2.42	353.47	+0.0723	−0.9753	+0.1968	...	...	...	...	504
−6.96	+2.43	354.55	+0.0727	−0.9756	+0.1955	...	...	...	...	505
−7.00	+2.44	...	...	...	...	281 13.68	+0.100	+1.884	+9.542	506
−7.01	+2.45	...	...	...	...	281 12.67	+0.102	+1.880	+9.535	506 bis
−7.04	+2.45	356.12	+0.0734	−0.9760	+0.1937	...	...	...	...	507
−7.08	+2.47	356.83	+0.0739	−0.9761	+0.1929	...	...	...	...	508
−7.13	+2.48	...	...	...	...	281 2.47	+0.104	+1.839	+9.475	509
−7.15	+2.48	...	...	...	...	281 0.17	+0.104	+1.830	+9.461	510
−7.18	+2.49	359.40	+0.0748	−0.9767	+0.1898	...	...	...	...	511
−7.23	+2.50	360.56	+0.0753	−0.9770	+0.1885	...	...	...	...	512
−7.27	+2.51	...	...	...	...	280 48.48	+0.106	+1.784	+9.393	513
+5.92	+2.26	...	...	...	...	270 24.21	+0.126	+0.038	+5.482	510
+5.55	+2.23	635.64	−0.0551	−0.9948	+0.0053	...	...	...	...	511
+5.49	+2.22	636.47	−0.0545	−0.9948	+0.0051	...	...	...	...	512
+5.42	+2.21	...	...	...	...	270 16.51	+0.121	+0.027	+5.422	513
+5.37	+2.20	...	...	...	...	270 15.73	+0.120	+0.025	+5.416	514
+5.35	+2.20	638.38	−0.0531	−0.9948	+0.0044	...	...	...	...	515
+5.28	+2.19	639.49	−0.0524	−0.9948	+0.0041	...	...	...	...	516
+5.19	+2.18	...	...	...	...	270 13.04	+0.119	+0.020	+5.396	517
−6.34	+2.29	...	...	...	...	265 41.60	+0.081	−0.219	+2.918	518
−6.36	+2.29	1181.26	+0.0611	−0.9920	−0.0751	...	...	...	...	519
−6.42	+2.30	1182.24	+0.0617	−0.9920	−0.0751	...	...	...	...	520
−6.47	+2.31	...	...	...	...	265 41.32	+0.081	−0.218	+2.913	521
−6.51	+2.32	...	...	...	...	265 41.27	+0.082	−0.218	+2.912	522
−6.56	+2.33	1184.53	+0.0631	−0.9920	−0.0752	...	...	...	...	523
−6.74	+2.36	1187.66	+0.0647	−0.9920	−0.0754	...	...	...	...	524
−6.81	+2.37	...	...	...	...	265 40.48	+0.083	−0.218	+2.897	525
−5.64	+2.21	...	...	...	...	125 17.78	+0.148	−5.867	−8.331	526
−5.69	+2.21	338.08	−0.0590	+0.8112	−0.5788	...	...	...	...	527
−5.75	+2.22	337.34	−0.0595	+0.8101	−0.5803	...	...	...	...	528
−5.79	+2.22	...	...	...	...	125 32.04	+0.158	−5.931	−8.348	529
−5.82	+2.23	...	...	...	...	125 34.66	+0.160	−5.942	−8.351	530
−5.87	+2.24	336.59	−0.0601	+0.8091	−0.5818	...	...	...	...	531
−5.94	+2.25	336.19	−0.0604	+0.8085	−0.5826	...	...	...	...	532
−6.12	+2.27	...	...	...	...	126 0.62	+0.181	−6.060	−8.381	533
−6.18	+2.28	...	...	...	...	126 6.36	+0.185	−6.085	−8.387	534
−6.22	+2.28	332.46	−0.0633	+0.8030	−0.5902	...	...	...	...	535
−6.29	+2.29	331.68	−0.0639	+0.8018	−0.5918	...	...	...	...	536
−6.35	+2.30	...	...	...	...	126 23.91	+0.198	−6.164	−8.405	537
−6.39	+2.30	...	...	...	...	126 27.62	+0.202	−6.181	−8.409	538
−6.43	+2.31	330.09	−0.0651	+0.7994	−0.5952	...	...	...	...	539
−6.48	+2.32	329.47	−0.0655	+0.7984	−0.5965	...	...	...	...	540
−6.55	+2.33	...	...	...	...	126 44.62	+0.214	−6.258	−8.426	541

No. of group — Date — Star of comparison	Rotation number	Time by chronometer	Local sidereal time	Greenwich sidereal time	Right ascension of star	Declination of star	Geocentric right ascension of planet	Geocentric declination of planet
		h. m. sec.	h. m. sec.	h. m. sec.				
	542	6 46 35	6 48 12	2 57 22	42° 6′ 31″·35	−5° 50′ 21″·74	42° 11′ 1″·86	−5° 53′ 40″·75
	544	6 48 40	6 50 17	2 59 27	,,	,,	1·30	40·79
LXXIX.	545	6 51 48	6 53 25	3 2 35	,,	,,	11 0·47	40·86
Nov. 29, 1874, morning	546	6 55 57	6 57 34	3 6 44	,,	,,	10 59·38	40·96
ν	547	6 59 20	7 0 57	3 10 7	,,	,,	58·49	41·04
	548	7 1 20	7 2 57	3 12 7	,,	,,	57·96	41·09
	549	7 6 51	7 8 28	3 17 38	,,	,,	56·50	41·21
	550	7 11 5	7 12 42	3 21 52	,,	,,	55·39	41·32
	551	0 19 28	0 21 7	20 30 17	42 6 31·37	−5 50 21·82	42 6 29·88	−5 53 59·27
	552	0 24 59	0 26 38	20 35 48	,,	,,	28·48	59·34
	553	0 27 45	0 29 24	20 38 34	,,	,,	27·78	59·37
LXXX.	554	0 34 15	0 35 54	20 45 4	,,	,,	26·14	59·45
Nov. 30, 1874, evening	555	0 36 36	0 38 15	20 47 25	,,	,,	25·55	59·48
ν	556	0 37 45	0 39 24	20 48 34	,,	,,	25·26	59·48
	557	0 40 37	0 42 16	20 51 26	,,	,,	24·54	59·52
	558	0 43 32·5	0 45 12	20 54 22	,,	,,	23·81	59·55
	559	0 45 11	0 46 50	20 56 0	42 6 31·37	−5 50 21·82	42 6 23·39	−5 53 59·57
	560	0 46 16	0 47 55	20 57 5	,,	,,	23·12	59·58
	561	0 48 40	0 50 19	20 59 29	,,	,,	22·51	59·61
LXXXI.	562	0 52 4	0 53 43	21 2 53	,,	,,	21·65	59·65
Nov. 30, 1874, evening	563	0 53 30	0 55 9	21 4 19	,,	,,	21·29	59·66
ν	564	0 54 44	0 56 23	21 5 33	,,	,,	20·98	59·68
	565	0 58 7	0 59 46	21 8 56	,,	,,	20·12	59·72
	566	1 0 28	1 2 7	21 11 17	,,	,,	19·54	59·74

Parallax in α	Parallax in Dec.	Distances				Position Angles				Rotation number
		Tabular distance	Par factor in distance	Factor for change of α	Factor for change of Dec.	Tabular position angle	Par. factor in pos. angle	Factor for change of α	Factor for change of Dec.	
		"	f'''	f'	f''		f'''	f'	f''	
−6·60	+2·34	...	...	...	...	126° 50′·36	+0·218	−6·283	−8·432	542
−6·63	+2·35	327·57	−0·0668	+0·7954	−0·6005	...	...	...	...	544
−6·68	+2·36	326·91	−0·0672	+0·7944	−0·6019	...	...	...	...	545
−6·75	+2·37	...	...	...	...	127 8·36	+0·229	−6·366	−8·450	546
−6·80	+2·38	...	...	...	...	127 14·91	+0·234	−6·396	−8·456	547
−6·83	+2·40	324·92	−0·0684	+0·7918	−0·6053	...	...	...	...	548
−6·90	+2·41	323·77	−0·0691	+0·7908	−0·6062	...	...	...	...	549
−6·97	+2·42	...	...	...	...	127 37·91	+0·248	−6·501	−8·476	550
+4·56	+2·10	...	...	...	...	179 11·25	−0·733	−15·961	−0·228	551
+4·44	+2·09	215·44	−0·0206	+0·0071	−1·0000	...	...	...	...	552
+4·34	+2·09	215·46	−0·0208	+0·0034	−1·0000	...	...	...	...	553
+4·15	+2·08	...	...	...	...	180 17·13	−0·660	−15·948	+0·080	554
+4·09	+2·08	...	...	...	...	180 27·44	−0·650	−15·946	+0·128	555
+4·06	+2·07	215·60	−0·0211	−0·0094	−1·0000	...	...	...	...	556
+3·98	+2·06	215·66	−0·0211	−0·0131	−0·9999	...	...	...	...	557
+3·90	+2·06	...	...	...	...	180 58·03	−0·616	−15·936	+0·271	558
+3·85	+2·05	...	...	...	...	181 5·47	−0·607	−15·932	+0·305	559
+3·82	+2·05	215·76	−0·0213	−0·0203	−0·9998	...	...	...	...	560
+3·75	+2·05	215·80	−0·0214	−0·0234	−0·9997	...	...	...	...	561
+3·66	+2·05	...	...	...	...	181 36·01	−0·573	−15·920	+0·447	562
+3·62	+2·04	...	...	...	...	181 42·34	−0·567	−15·917	+0·477	563
+3·59	+2·04	215·93	−0·0215	−0·0312	−0·9995	...	...	...	...	564
+3·48	+2·03	216·01	−0·0215	−0·0356	−0·9994	...	...	...	...	565
+3·40	+2·03	...	...	...	...	182 13·47	−0·528	−15·900	+0·621	566

CHAPTER IX.

COMPARISON OF OBSERVED AND TABULAR DISTANCES AND POSITION ANGLES.

FROM the tables contained in the last chapter, and the observations in the chapter immediately preceding, we can now obtain comparisons of observed and tabular position angles and distances in the following table, for the formation of the equations of condition.

Column 1 contains the number of the group and star of comparison and the date.

„ 2. The rotation number of the observations of position angles.

„ 3. The Greenwich sidereal time.

„ 4. The position angle as observed.

„ 5. The correction for refraction in position angle.

„ 6. The observed position angle corrected for refraction, and approximate index correction assumed to be throughout $-3'{\cdot}00$.

Column 7. The calculated tabular position angle from Table VI.

„ 8. The resulting comparison of observed and calculated place c–o.

„ 9 contains the rotation number.

„ 10. The Greenwich sidereal time of the observations of distance.

„ 11. The distance in screw revolutions (from table of observation).

„ 12. The refraction in screw revolutions.

„ 13. The observed distance in screw revolutions.

„ 14. The true distance converted into arc 1 revolution $= 25''{\cdot}728924$, as derived from the observations of the Hydra and Perseus zones at Mauritius, pp. 125–128.

Column 15. The calculated tabular distance.

„ 16. The resulting comparison of observed and calculated distance c–o.

No. of group — Name of objects — Date	Position Angles: Rotation number	Greenwich sidereal time	Observed position angle	Refraction	Obs. pos. ang. = mean + app. index correction	Computed position angle	C–O and mean	Distances: Rotation number	Greenwich sidereal time	Sc. A–Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Observed dist. in arc	Computed dist.	C–O and mean
		h. m. sec.	° ′	′	° ′	° ′	′		h. m. sec.	rev.	rev.	rev.	″	″	″
I. Juno & ζ November 10, 1874	1	19 24 20	259 35·5	−0·51	259 31·99	259 32·30	+ 0·31	2	19 24 20	+167·6547	0·1508	167·8055	4317·455	4325·27	+ 7·815
	4	19 33 58	259 35·0	−0·45	259 32·55	259 30·41	− 2·14	3	19 33 58	−167·9229	0·1351	168·0580	4323·951	4330·22	+ 6·269
	4 bis	19 40 25	259 32·5	−0·41	259 29·09	259 29·17	+ 0·08	5	19 40 25	−168·0746	0·1250	168·1996	4327·595	4333·51	+ 5·915
	7	19 50 37	259 30·0	−0·37	259 26·63	259 27·18	+ 0·55	6	19 50 37	+168·3250	0·1126	168·4376	4333·718	4338·76	+ 4·042
App. index corr. −1·6400							− 0·30								...
II. Juno & κ November 10, 1874	8	20 14 28	101 55·0	−0·49	101 51·51	101 50·57	− 0·94	9	20 14 28	−229·5141	0·1008	229·6149	5907·745	5902·39	− 5·355
	11	20 21 13	101 51·5	−0·45	101 48·05	101 52·23	+ 4·18	10	20 21 13	+229·3231	0·0962	229·4193	5902·712	5899·79	− 2·922
	11	20 21 13	101 51·5	−0·45	101 48·05	101 52·23	+ 4·18	12	20 17 5	+229·2190	0·0990	229·3180	5900·106	5901·43	+ 1·324
	14	20 27 3	101 58·0	−0·41	101 54·59	101 53·66	− 0·93	13	20 27 3	−229·3325	0·0927	229·4252	5902·864	5897·53	− 5·334
App. index corr. −1·6400							+ 1·63								...
III. Juno & κ November 10, 1874	15	20 37 13	101 58·0	−0·36	101 54·64	101 56·17	+ 1·53	16	20 37 13	−229·1522	0·0872	229·2394	5898·084	5893·61	− 4·474
	18	20 41 31	101 58·0	−0·34	101 54·66	101 57·23	+ 2·67	17	20 41 31	+229·1513	0·0852	229·2365	5898·009	5891·92	− 6·089
	18 bis	20 44 57	101 58·5	−0·32	101 55·18	101 58·07	+ 2·89	19	20 44 57	+229·0036	0·0837	229·0873	5894·170	5890·58	− 3·590
	21	20 50 10	102 2·5	−0·30	101 59·20	101 59·38	+ 0·18	20	20 50 10	−228·9754	0·0814	229·0568	5893·385	5888·54	− 4·845
App. index corr. −1·6400							+ 1·80								...
IV. Juno & ζ November 10, 1874	22	21 11 53	259 12·5	−0·17	259 9·33	259 11·68	+ 2·35	23	21 11 53	+170·9217	0·0628	170·9845	4399·247	4381·04	− 18·207
	25	21 15 59	259 13·0	−0·16	259 9·84	259 10·90	+ 1·06	24	21 15 59	−170·0592	0·0616	170·1208	4377·025	4383·19	+ 6·165
App. index corr. −1·6400							+ 1·71								...
V. Juno & ζ November 10, 1874	26	3 2 25·5	258 14·0	+1·20	258 12·20	258 9·48	− 2·72	27	3 4 50·5	−177·0480	0·1396	177·1876	4558·847	4566·49	+ 7·643
	29	3 9 0·5	258 11·5	+1·34	258 9·84	258 8·38	− 1·46	28	3 10 53·5	+177·2431	0·1510	177·3941	4564·459	4569·59	+ 5·131
	29 bis	3 13 55·5	258 10·0	+1·47	258 8·47	258 7·53	− 0·94	30	3 16 19·5	+177·2290	0·1623	177·3913	4564·087	4572·38	+ 8·293
	32	3 20 0·5	258 9·5	+1·64	258 8·14	258 6·51	− 1·63	31	3 19 20·5	−177·4565	0·1701	177·6266	4570·142	4573·93	+ 3·788
App. index corr. −1·6400							− 1·69								...
VI. Juno & κ November 10, 1874	33	3 28 47·5	103 34·0	+0·64	103 31·64	103 39·71	+ 8·07	34	3 30 11·5	−222·7759	0·3556	223·1315	5740·934	5734·66	− 6·274
	36	3 40 45·5	103 34·5	+0·79	103 32·29	103 42·76	+10·47	35	3 36 45·5	+222·5854	0·4015	222·9869	5737·213	5732·31	− 4·903
	36	3 40 45·5	103 34·5	+0·79	103 32·29	103 42·76	+10·47	37	3 41 57·5	+222·5828	0·4449	223·0277	5738·263	5730·40	− 7·863
	39	3 50 40·5	103 38·0	+0·96	103 35·96	103 45·27	+ 9·31	38	3 45 50·5	−222·3737	0·4826	222·8563	5733·853	5729·02	− 4·833
App. index corr. −1·6400							+ 9·58								...
VII. Juno & κ November 10, 1874	40	3 53 35·5	103 37·5	+1·02	103 35·52	103 46·02	+10·50	Distances were not observed							
	41	3 56 40·5	103 38·5	+1·09	103 36·59	103 46·79	+10·20								
App. index corr. ...							+10·35								
VIII. Juno & ζ November 10, 1874	42	4 1 25·5	258 0·0	+4·01	258 1·01	257 59·52	− 1·49	Distances were not observed							
	43	4 6 40·5	258 0·0	+4·62	258 1·62	257 58·65	− 2·97								
App. index corr. ...							− 2·23								

No. of group — Name of objects — Date	Position Angles							Distances							
	Rotation number	Greenwich sidereal time	Observed position angle	Refraction	Obs. pos. ang. = mean + app. index correction	Computed position angle	C–O and mean	Rotation number	Greenwich sidereal time	Sc. A – Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Observed dist. in arc	Computed dist.	C–O and mean
		h. m. sec.	° ′	′	° ′	° ′	′		h. m. sec.	rev.	rev.	rev.	″	″	″
IX.	44	18 32 30	255 44·0	−0·79	255 40·21	255 42·98	+2·77	...	...	...	...	...	...	...	...
Juno & *z*	47	18 40 59·5	255 45·5	−0·67	255 41·83	255 41·79	−0·04	...	...	...	...	...	...	...	...
November 11, 1874	47	18 40 59·5	255 45·5	−0·67	255 41·83	255 41·79	−0·04	...	...	...	...	...	...	...	...
	50	18 54 55	255 40·5	−0·53	255 36·97	255 39·89	+2·92	...	...	...	...	...	...	...	...
App. index corr. ...							+1·40								...
X.	51	18 34 26	75 54·5	−0·71	75 50·79	75 46·52	−4·27	52	18 36 26	+35·4780	0·0635	35·5415	914·445	909·38	−5·065
Juno & *θ*	54	18 42 36	75 59·5	−0·61	75 55·89	75 52·30	−3·59	53	18 39 50	−35·4106	0·0595	35·4701	912·608	907·66	−4·948
November 12, 1874	54 bis	18 50 36	76 6·0	−0·55	76 2·45	75 57·95	−4·50	55	18 53 17	−35·1611	0·0475	35·2086	905·879	900·80	−5·079
	57	19 0 23	76 11·0	−0·49	76 7·51	76 5·07	−2·44	56	18 57 52	+35·0171	0·0433	35·0604	902·066	898·46	−3·606
App. index corr. −1·6358							−3·70								−4·675
XI.	58	19 6 58	76 12·5	−0·45	76 9·05	76 9·76	+0·71	59	19 8 3	+34·8415	0·0371	34·8786	897·388	893·24	−4·148
Juno & *θ*	61	19 14 59	76 26·0	−0·41	76 22·59	76 15·64	−6·95	60	19 12 8	−34·7729	0·0349	34·8078	895·567	891·12	−4·447
November 12, 1874	61 bis	19 19 44	76 23·0	−0·40	76 19·60	76 16·50	−3·10	62	19 19 44	−34·6356	0·0315	34·6671	891·947	887·25	−4·697
	64	19 27 18	76 30·0	−0·36	76 26·64	76 24·76	−1·88	63	19 22 59	+34·5811	0·0302	34·6113	890·511	885·55	−4·961
App. index corr. −1·6358							−2·80								−4·563
XII.	65	19 36 48	76 35·5	−0·33	76 32·17	76 31·75	−0·42	66	19 39 17	+34·1946	0·0249	34·2195	880·430	877·18	−3·250
Juno & *θ*	68	19 48 7	76 46·0	−0·30	76 42·70	76 40·25	−2·45	67	19 43 42	−34·1600	0·0237	34·1837	879·509	874·91	−4·599
November 12, 1874	68 bis	19 50 21	76 50·5	−0·29	76 47·21	76 42·01	−5·20	69	19 51 49	−33·9816	0·0217	34·0033	874·868	870·70	−4·168
	71	19 59 1	76 48·0	−0·27	76 44·73	76 48·55	+3·82	70	19 56 16	+33·9028	0·0208	33·9236	872·818	868·41	−4·408
App. index corr. −1·6358							−1·06								−4·106
XIII.	72	20 7 49	76 55·0	−0·25	76 51·75	76 55·27	+3·52	73	20 9 16	+33·6437	0·0184	33·6621	866·089	861·72	−4·369
Juno & *θ*	75	20 18 54	77 15·0	−0·23	77 11·77	77 3·89	−7·88	74	20 14 3	−33·5109	0·0177	33·5286	862·654	859·25	−3·404
November 12, 1874															
App. index corr. −1·6358							−2·18								−3·887
XIV.	76	1 24 33·5	81 55·0	+0·30	81 52·30	81 48·39	−3·91	77	1 26 10·5	+27·3397	0·0102	27·3499	703·683	698·61	−5·073
Juno & *θ*	79	1 34 15·5	82 2·5	+0·34	81 59·84	81 59·40	−0·44	78	1 31 13·5	−27·2487	0·0105	27·2592	701·350	696·08	−5·270
November 12, 1874	79 bis	1 38 19·5	82 12·5	+0·36	82 9·86	82 4·09	−5·77	80	1 40 25·5	−27·0257	0·0110	27·0367	695·625	691·51	−4·115
	82	1 50 41·5	82 14·5	+0·42	82 11·92	82 18·40	+6·48	81	1 43 9·5	+26·9937	0·0112	27·0049	694·807	690·17	−4·637
App. index corr. −1·6279							−0·91								−4·773
XV.	83	2 0 19·5	82 35·0	+0·48	82 32·48	82 29·76	−2·72	84	2 2 42·5	+26·6213	0·0126	26·6339	685·261	680·47	−4·791
Juno & *θ*	86	2 12 49·5	82 47·5	+0·57	82 45·07	82 44·61	−0·46	85	2 6 30·5	−26·5560	0·0130	26·5690	683·592	678·58	−5·012
November 12, 1874	86 bis	2 14 27·5	82 56·0	+0·58	82 53·58	82 46·65	−6·93	87	2 18 39·5	−26·3000	0·0142	26·3142	677·036	672·61	−4·426
	89	2 27 30·5	83 8·0	+0·69	83 5·69	83 2·50	−3·19	88	2 22 52·5	+26·2055	0·0147	26·2202	674·617	670·56	−4·057
App. index corr. −1·6279							−3·33								−4·572
XVI.	90	2 36 30	83 15·5	+0·79	83 13·29	83 13·59	+0·30	91	2 37 55	+25·9348	0·0169	25·9517	667·709	663·19	−4·519
Juno & *θ*	93	2 45 26	83 29·5	+0·90	83 27·40	83 24·76	−2·64	92	2 42 45	−25·8523	0·0177	25·8700	665·607	660·85	−4·757
November 12, 1874	93	2 45 26	83 29·5	+0·90	83 27·40	83 24·76	−2·64	94	2 47 23	−25·7334	0·0186	25·7520	662·571	658·59	−3·981
	96	2 54 35	83 36·5	+1·03	83 34·53	83 36·44	+1·91	95	2 52 0	+25·6747	0·0198	25·6945	661·092	656·35	−4·742
App. index corr. −1·6279							−0·77								−4·500

No. of group — Name of objects — Date	Position Angles							Distances							
	Rotation number	Greenwich sidereal time	Observed position angle	Refraction	Obs. pos. ang. = mean + app. index correction	Computed position angle	C–O and mean	Rotation number	Greenwich sidereal time	Sc. A – Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Observed dist. in arc	Computed dist.	C–O and mean
		h. m. sec.	° ′	′	° ′	° ′	′		h. m. sec.	rev.	rev.	rev.	″	″	″
XVII. Juno & θ November 12, 1874	97	3 4 1	83 53·0	+1·20	83 51·20	83 48·59	− 2·61	98	3 5 16·5	+25·4031	0·0229	25·4260	654·183	649·94	−4·243
	100	3 12 21	84 9·5	+1·38	84 7·88	83 59·48	− 8·40	99	3 9 30	−25·3416	0·0242	25·3658	652·634	647·91	−4·724
	100 bis	3 15 30	84 9·0	+1·45	84 7·45	84 3·56	− 3·89	101	3 16 44	−25·1909	0·0268	25·2177	648·824	644·44	−4·384
	103	3 24 22	84 17·5	+1·70	84 16·20	84 15·33	− 0·87	102	3 21 3	+25·1160	0·0286	25·1446	646·943	642·37	−4·573
App. index corr. −1·6279							− 3·94								−4·481
XVIII. Juno & θ November 13, 1874	104	18 22 2	126 52·0	−3·68	126 45·32	127 1·25	+15·93	105	18 24 51·5	+12·9571	0·0110	12·9681	333·655	330·33	−3·325
	107	18 32 26	127 31·0	−2·78	127 25·22	127 55·41	+30·19	106	18 29 29	−12·9162	0·0101	12·9263	332·580	329·52	−3·060
	107 bis	18 33 42	127 47·0	−2·70	127 41·30	128 2·18	+20·88	108	18 35 29·5	−12·8707	0·0090	12·8797	331·381	328·48	−2·901
	110	18 41 21	128 18·0	−2·26	128 12·74	128 42·48	+29·74	109	18 38 21	+12·8601	0·0085	12·8686	331·095	328·02	−3·075
App. index corr. −1·6478							+24·18								−3·090
XIX. Juno & θ November 13, 1874	111	18 51 34	129 20·0	−1·80	129 15·20	129 37·04	+21·84	112	18 52 34	+12·7849	0·0068	12·7917	329·117	325·70	−3·417
	114	18 57 56	129 43·5	−1·58	129 38·92	130 11·35	+32·43	113	18 55 6	−12·7748	0·0066	12·7814	328·852	325·30	−3·552
	114 bis	18 58 52	129 55·5	−1·55	129 50·95	130 16·32	+25·37	115	19 0 6	−12·7241	0·0062	12·7303	327·537	324·54	−2·997
	117	19 5 16·5	130 28·0	−1·36	130 23·64	130 51·24	+27·60	116	19 2 16	+12·7235	0·0060	12·7295	327·516	324·22	−3·296
App. index corr. −1·6478							+26·81								−3·316
XX. Juno & θ November 13, 1874	118	19 14 17	131 9·0	−1·13	131 4·87	131 40·29	+35·42	119	19 15 51	+12·6213	0·0052	12·6265	324·866	322·24	−2·626
	121	19 20 53	131 47·0	−1·00	131 43·00	132 16·97	+33·97	120	19 18 43	−12·6231	0·0051	12·6282	324·910	321·82	−3·090
	121 bis	19 22 36·5	132 6·0	−0·96	132 2·04	132 26·44	+24·40	122	19 23 46·5	−12·5927	0·0048	12·5975	324·120	321·14	−2·980
	124	19 31 34·5	132 52·0	−0·81	132 48·19	133 16·37	+28·18	123	19 28 19·5	+12·5641	0·0047	12·5688	323·381	320·51	−2·871
App. index corr. −1·6478							+30·49								−2·892
XXI. Juno & θ November 13, 1874	125	19 47 16·5	134 12·5	−0·60	134 8·90	134 44·95	+36·05	126	19 48 45	+12·4560	0·0041	12·4601	320·585	317·96	−2·625
	128	19 55 46	135 14·0	−0·51	135 10·49	135 33·32	+22·83	127	19 51 49	−12·4508	0·0040	12·4548	320·449	317·61	−2·839
	128 bis	19 56 49	135 14·5	−0·49	135 11·01	135 39·37	+28·36	129	19 58 4	−12·4052	0·0039	12·4091	319·273	316·90	−2·373
	131	20 4 29	135 51·5	−0·42	135 48·08	136 23·20	+35·12	130	20 0 54·5	+12·4054	0·0038	12·4092	319·276	316·61	−2·666
App. index corr. −1·6478							+30·59								−2·626
XXII. Juno & θ November 13, 1874	132	2 8 57	170 56·5	−0·39	170 53·11	171 29·50	+36·39	133	2 11 43·5	+13·0702	0·0047	13·0749	336·403	337·31	+0·907
	135	2 23 11	172 3·0	−0·48	171 59·52	172 39·97	+40·45	134	2 16 41	−13·1699	0·0047	13·1746	338·968	338·38	−0·588
	135 bis	2 25 47	172 10·0	−0·50	172 6·50	172 52·81	+46·31	136	2 26 43·5	−13·2511	0·0049	13·2560	341·062	340·58	−0·482
	138	2 33 46·5	173 6·0	−0·56	173 2·44	173 31·65	+29·21	137	2 29 39·5	+13·2623	0·0049	13·2672	341·351	341·24	−0·111
App. index corr. −1·6488							+38·09								−0·069
XXIII. Juno & θ November 13, 1874	139	2 44 49	173 50·0	−0·66	173 46·34	174 24·41	+38·07	140	2 46 2	+13·4152	0·0051	13·4203	345·290	345·01	−0·280
	142	2 52 8	174 5·0	−0·73	174 1·27	174 58·77	+57·50	141	2 49 46	−13·4883	0·0052	13·4935	347·173	345·90	−1·273
	142 bis	2 54 38	174 31·5	−0·76	174 27·74	175 10·49	+42·75	143	3 12 30	−13·6260	0·0057	13·6317	350·729	351·50	+0·771
	145	3 20 18	176 41·0	−1·16	176 36·84	177 7·72	+30·88	144	3 16 32	+13·6962	0·0058	13·7020	352·537	352·52	−0·017
App. index corr. −1·6488							+42·30								−0·200
XXIV. Juno & θ November 13, 1874	146	3 35 15	177 33·0	−1·53	177 28·47	178 13·60	+45·13	147	3 37 2·5	+13·8939	0·0065	13·9004	357·642	357·88	+0·238
	149	3 44 8·5	178 12·5	−1·84	178 7·66	178 51·63	+43·97	148	3 40 2	−13·9249	0·0066	13·9315	358·443	358·66	+0·217
	150α	4 5 41·5	179 28·5	−3·09	179 22·41	180 22·10	+59·69	150	4 7 17	−14·2128	0·0087	14·2215	365·904	366·19	+0·286
	152	4 11 46·5	180 33·5	−3·68	180 26·82	180 46·89	+20·07	151	4 9 12	+14·2773	0·0089	14·2862	367·568	366·74	−0·828
App. index corr. −1·6488							+42·22								−0·021

No. of group — Name of objects — Date	Position Angles							Distances							
	Rotation number	Greenwich sidereal time	Observed position angle	Refraction	Obs. pos. ang. = mean + app. index correction	Computed position angle	C–O and mean	Rotation number	Greenwich sidereal time	Sc. A – Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Observed dist. in arc	Computed dist.	C–O and mean
		h. m. sec.	° ′	′	° ′	° ′	″		h. m. sec.	rev.	rev.	rev.	″	″	″
XXV.	153	3 45 56	178 25·5	−1·91	178 20·59	178 59·14	+38·55	154	3 47 58	− 14·0001	0·0071	14·0072	360·390	360·82	+0·430
Juno & θ	156	3 55 27	179 16·5	−2·43	179 11·07	179 39·71	+28·64	155	3 52 13	+ 14·1048	0·0073	14·1121	363·089	362·00	−1·089
November 13, 1874	156	3 55 27	179 16·5	−2·43	179 11·07	179 39·71	+28·64	157	3 56 45·5	+ 14·0985	0·0077	14·1062	362·937	363·25	+0·313
	159	4 3 45	179 31·5	−2·93	179 25·57	180 14·16	+48·59	158	4 1 34	− 14·1711	0·0081	14·1792	364·816	364·59	−0·226
App. index corr. −1·6488							+36·10								−0·143
XXVI.	160	3 3 19	...	+0·42	...	104 24·82	...	161	3 12 16	+175·7473	0·0640	175·8113	4523·435	4518·77	−4·665
Juno & λ	163	3 22 11	104 29·5	+0·53	104 27·03	104 30·08	+ 3·05	162	3 17 13	−175·6425	0·0657	175·7082	4520·783	4516·97	−3·813
November 14, 1874	163 bis	3 23 47	104 31·0	+0·55	104 28·55	104 30·51	+ 1·96	164	3 28 12·5	−175·4902	0·0702	175·5604	4516·980	4513·00	−3·980
	166	3 37 5	104 39·0	+0·67	104 36·67	104 34·23	− 2·44	165	3 33 26	+175·3763	0·0728	175·4491	4514·117	4511·15	−2·967
App. index corr. −1·6400							...								−3·856
XXVII.	167	3 44 58	311 33·5	−1·85	311 28·65	311 22·72	− 5·93	168	3 46 35	+177·8983	0·3225	178·2208	4585·429	4586·95	...
Juno & ζ	170	3 57 47	311 25·5	−2·58	311 19·92	311 18·06	− 1·86	169	3 52 32	−177·9805	0·3654	178·3459	4588·648	4587·83	...
November 14, 1874	170	3 57 47	311 25·5	−2·58	311 19·92	311 18·06	− 1·86	171*a*	4 4 16	−177·9346	0·4814	178·4160	4590·451	4589·60	...
	173	4 13 18	311 25·0	−4·12	311 17·88	311 12·43	− 5·45	172	4 9 47	+177·9798	0·5569	178·5367	4593·556	4590·42	...
App. index corr. −1·6400							− 3·78								...
XXVIII.	176	19 58 48	305 57·5	−0·62	305 53·88	305 52·72	− 1·16	177	19 59 55·5	+183·9415	0·0675	184·0090	4734·354	4738·68	+4·326
Juno & ζ	179	20 5 6	305 56·7	−0·56	305 53·14	305 50·57	− 2·57	178	20 2 57·5	−183·9958	0·0665	184·0623	4735·725	4739·32	+3·595
November 15, 1874	180	20 6 58	305 55·5	−0·54	305 51·96	305 49·94	− 2·02	181	20 8 8	−184·0700	0·0649	184·1349	4737·593	4740·39	+2·797
	183	20 17 6	305 52·0	−0·46	305 48·54	305 46·50	− 2·04	182	20 11 24·5	+184·0778	0·0640	184·1418	4737·770	4741·07	+3·300
App. index corr. −1·6391							− 1·95								+3·505
XXIX.	184	20 25 18·5	109 29·0	−0·42	109 25·58	109 29·38	+ 3·80	185	20 27 11·5	+163·0016	0·0608	163·0624	4195·421	4190·55	−4·871
Juno & λ	187	20 33 21·5	109 34·5	−0·38	109 31·12	109 31·97	+ 0·85	186	20 30 32	−162·9433	0·0597	163·0030	4193·892	4189·42	−4·472
November 15, 1874	187 bis	20 35 3·5	109 34·5	−0·37	109 31·12	109 32·52	+ 1·40	188	20 41 8·5	−162·7751	0·0566	162·8317	4189·485	4185·86	−3·625
	190	20 49 7·5	109 37·5	−0·30	109 34·20	109 37·05	+ 2·85	189	20 45 48	+162·7266	0·0554	162·7820	4188·206	4184·29	−3·916
App. index corr. −1·6391							+ 2·22								−4·221
XXX.	191	20 54 11	109 38·5	−0·27	109 35·23	109 38·68	+ 3·45	192	20 55 48·5	+162·6160	0·0532	162·6692	4185·304	4180·94	−4·364
Juno & λ	194	21 3 59·5	109 44·5	−0·24	109 41·26	109 41·87	+ 0·61	193	21 0 38·5	−162·5419	0·0522	162·5941	4183·371	4179·30	−4·071
November 15, 1874	194 bis	21 5 19	109 45·0	−0·23	109 41·77	109 42·30	+ 0·53	195	21 6 23·5	−162·4837	0·0512	162·5349	4181·848	4177·36	−4·488
	197	21 13 16	109 45·0	−0·20	109 41·80	109 44·87	+ 3·07	196	21 9 19·5	+162·4383	0·0507	162·4890	4180·668	4176·38	−4·288
App. index corr. −1·6391							+ 1·91								−4·303
XXXI.	198	21 18 39	305 30·0	−0·16	305 26·84	305 25·54	− 1·30	199	21 19 36·5	+184·6243	0·0529	184·6772	4751·545	4755·72	+4·175
Juno & ζ	201	21 26 31·5	305 28·5	−0·14	305 25·36	305 22·85	− 2·51	200	21 23 16	−184·6538	0·0526	184·7064	4752·297	4756·52	+4·223
November 15, 1874	201	21 26 31·5	305 28·5	−0·14	305 25·36	305 22·85	− 2·51	202	21 27 40·5	−184·7189	0·0522	184·7711	4753·961	4757·48	+3·519
	204	21 34 10	305 25·0	−0·12	305 21·88	305 20·26	− 1·62	203	21 31 27	+184·7647	0·0520	184·8167	4755·134	4758·30	+3·166
App. index corr. −1·6391							− 1·98								+3·771
XXXII.	205	1 35 31	304 3·0	−0·02	303 59·98	303 59·56	− 0·42	206	1 37 28·5	+186·8597	0·0834	186·9431	4809·845	4814·32	+4·475
Juno & ζ	208	1 44 44	304 3·5	−0·04	304 0·46	303 56·56	− 3·90	207	1 41 3	−186·9068	0·0853	186·9921	4811·106	4815·12	+4·014
November 15, 1874	209	1 46 51	304 3·0	−0·04	303 59·96	303 55·87	− 4·09	210	1 48 39	−186·9716	0·0896	187·0612	4812·884	4816·89	+4·006
	212	1 56 27·5	303 59·5	−0·07	303 56·43	303 52·73	− 3·70	211	1 52 51	+187·0053	0·0922	187·0975	4813·818	4817·84	+4·022
App. index corr. −1·6331							− 3·04								+4·129

No. of group — Name of objects — Date	Position Angles							Distances							
	Rotation number	Greenwich sidereal time	Observed position angle	Refraction	Obs. pos. ang. = mean + app. index correction	Computed position angle	C–O and mean	Rotation number	Greenwich sidereal time	Sc. A – Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Observed dist. in arc	Computed dist.	C–O and mean
		h. m. sec.	° ′	′	° ′	° ′	′		h. m. sec.	rev.	rev.	rev.	″	″	″
XXXIII. Juno & λ November 15, 1874	213	2 3 11·5	111 22·5	+0·12	111 19·62	111 20·52	+0·90	214	2 4 51·5	+158·5758	0·0911	158·6669	4082·329	4077·47	−4·859
	216	2 12 4·5	111 27·0	+0·11	111 24·11	111 23·47	−0·64	215	2 8 38·5	−158·5157	0·0941	158·6098	4080·859	4076·24	−4·619
	217	2 14 31·5	111 27·0	+0·11	111 24·11	111 24·28	+0·17	218	2 16 48·5	−158·3937	0·1012	158·4949	4077·903	4073·63	−4·273
	220	2 24 24·5	111 29·5	+0·10	111 26·60	111 27·57	+0·97	219	2 21 11·5	+158·3436	0·1054	158·4490	4076·723	4072·22	−4·503
App. index corr. −1·6331							+0·35								−4·564
XXXIV. Juno & λ November 15, 1874	221	2 30 52·5	111 31·5	+0·10	111 28·60	111 29·72	+1·12	222	2 33 55	+158·1633	0·1198	158·2831	4072·454	4068·14	−4·314
	224	2 40 21·5	111 36·0	+0·09	111 33·09	111 32·86	−0·23	223	2 37 17·5	−158·1352	0·1243	158·2595	4071·846	4067·08	−4·766
	225	2 42 56·5	111 36·0	+0·09	111 33·09	111 33·74	+0·65	226 bis	2 48 30·5	−157·9843	0·1414	158·1257	4068·404	4063·51	−4·894
	228	2 56 24·5	111 39·0	+0·08	111 36·08	111 38·21	+2·13	227	2 53 51	+157·9062	0·1510	158·0572	4066·641	4061·83	−4·811
App. index corr. −1·6331							+0·92								−4·696
XXXV. Juno & ζ November 15, 1874	229	3 4 7	303 36·5	−0·44	303 33·06	303 30·96	−2·10	230	3 6 43	+187·5573	0·1909	187·7482	4830·559	4834·69	+4·131
	232	3 14 10	303 35·5	−0·56	303 31·94	303 27·77	−4·17	231	3 11 6·5	−187·5903	0·2029	187·7932	4831·717	4835·68	+3·963
	233	3 17 59	303 35·5	−0·61	303 31·89	303 26·56	−5·33	234	3 19 24	−187·6393	0·2292	187·8685	4833·655	4837·57	+3·915
	236	3 28 14	303 30·0	−0·78	303 26·22	303 23·31	−2·91	235	3 24 32	+187·6910	0·2481	187·9391	4835·471	4838·72	+3·249
App. index corr. −1·6331							−3·63								+3·815
XXXVI. Juno & ζ November 15, 1874	237	3 30 44	303 29·5	−0·83	303 25·67	303 22·51	−3·16	238	3 32 12·5	+187·7062	0·2827	187·9889	4836·752	4840·43	+3·678
	240	3 39 24	303 27·5	−1·03	303 23·47	303 19·77	−3·70	239	3 36 2	−187·7439	0·3024	188·0463	4838·129	4841·27	+3·141
	240	3 39 24	303 27·5	−1·03	303 23·47	303 19·77	−3·70	241	3 40 57	−187·7233	0·3314	188·0545	4838·440	4842·38	+3·940
	243	3 49 12	303 24·5	−1·32	303 20·18	303 16·69	−3·49	242	3 46 17	+187·7968	0·3689	188·1657	4841·302	4843·58	+2·278
App. index corr. −1·6331							−3·51								+3·259
XXXVII. Juno & λ November 15, 1874	244	4 8 16·5	112 13·5	−0·30	112 10·20	112 2·08	−8·12	245	4 9 56·5	+156·3932	0·6657	157·0589	4040·956	4038·30	−2·656
	247	4 18 0·5	112 9·5	−0·50	112 6·00	112 5·31	−0·69.	246	4 13 41·5	−156·3307	0·7068	157·0375	4040·406	4037·16	−3·246
App. index corr. −1·6331							−4·41								−2·951
XXXVIII. Juno & ι November 17, 1874	248	19 19 3	306 59·0	−1·17	306 54·83	300 43·75	Wrong star observed	249	19 23 31	...	0·0614	...	...	3151·60	Wrong star observed
	251	19 30 39·5	307 11·5	−0·97	307 7·53	300 38·59		250	19 28 3	...	0·0593	...	...	3152·70	
	252	19 33 24	307 10·0	−0·94	307 6·06	300 37·36		253	19 34 33	...	0·0563	...	...	3154·29	
	255	19 45 28·5	306 55·0	−0·78	306 51·22	300 31·98		254	19 41 58	...	0·0534	...	...	3156·10	
App. index corr. ...							...								...
XXXIX. Juno & θ November 18, 1874	256	19 2 15	233 59·0	+0·64	233 56·64	234 1·11	+4·47	257	19 3 46	+132·1909	0·1386	132·3295	3404·695	3406·19	+1·495
	259	19 21 19	234 4·0	+0·42	234 1·42	234 2·56	+1·14	258	19 6 13	−132·2407	0·1342	132·3749	3405·864	3407·33	+1·466
	260	19 24 11·5	234 4·0	+0·39	234 1·39	234 2·77	+1·38	261	19 29 44·5	−132·7019	0·1015	132·8034	3416·888	3418·20	+1·312
	263	19 38 7·5	234 2·5	+0·28	233 59·78	234 3·84	+4·06	262	19 33 27	+132·7829	0·0977	132·8806	3418·874	3419·92	+1·046
App. index corr. −1·6400							+2·76								+1·330
XL. Juno & θ November 18, 1874	264	1 42 8	234 34·5	+0·36	234 31·86	234 33·36	+1·50	265	1 45 20	+139·5508	0·0452	139·5960	3591·654	3594·16	+2·506
	267	1 53 48	234 38·5	+0·44	234 35·94	234 34·24	−1·70	266	1 50 57	−139·7206	0·0462	139·7668	3596·049	3596·75	+0·701
	268	1 55 5	234 37·5	+0·45	234 34·95	234 34·35	−0·60	269	1 56 42	−139·8245	0·0473	139·8718	3598·750	3599·40	+0·650
	271	2 5 46	234 35·5	+0·55	234 33·05	234 35·19	+2·14	270	2 0 52	+139·8821	0·0481	139·9302	3600·253	3601·31	+1·057
App. index corr. −1·6476							+0·33								+1·229

No. of group — Name of objects — Date	Position Angles							Distances							
	Rotation number	Greenwich sidereal time	Observed position angle	Refraction	Obs. pos. ang. = mean + app. index correction	Computed position angle	C–O and mean	Rotation number	Greenwich sidereal time	Sc. A – Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Observed dist. in arc	Computed dist.	C–O and mean
		h. m. sec.	° ′	′	° ′	° ′	′		h. m. sec.	rev.	rev.	rev.	″	″	″
XLI. Juno & μ November 18, 1874	272	2 15 21	66 15·5	+0·72	66 13·22	66 10·88	−2·34	273	2 16 54	+159·7862	0·0723	159·8585	4112·988	4109·60	−3·388
	275	2 31 11	66 17·0	+0·92	66 14·92	66 11·07	−3·85	274	2 22 15	−159·6976	0·0752	159·7728	4110·782	4107·13	−3·652
	276	2 34 11	66 16·0	+0·96	66 13·96	66 11·12	−2·84	277	2 35 21	−159·4504	0·0836	159·5340	4104·638	4101·06	−3·578
	279	2 43 49·5	66 17·0	+1·12	66 15·12	66 11·25	−3·87	278	2 39 36·5	+159·3971	0·0869	159·4840	4103·352	4099·07	−4·282
App. index corr. −1·6476							−3·23								−3·724
XLII. Juno & μ November 18, 1874	280	2 50 54	66 15·5	+1·26	66 13·76	66 11·35	−2·41	281	2 52 5	+159·1442	0·0981	159·2423	4097·133	4093·32	−3·813
	283	3 0 9	66 17·0	+1·48	66 15·48	66 11·45	−4·03	282	2 56 18	−159·0268	0·1026	159·1294	4094·228	4091·36	−2·868
	284	3 2 31·5	66 17·0	+1·55	66 15·55	66 11·48	−4·07	285	3 3 44	−158·9667	0·1118	159·0785	4092·919	4087·94	−4·979
	287	3 12 49	66 15·0	+1·87	66 13·87	66 11·61	−2·26	286	3 7 59	+158·8679	0·1177	158·9856	4090·528	4086·06	−4·468
App. index corr. −1·6476							−3·19								−4·032
XLIII. Juno & θ November 18, 1874	288	3 22 9	234 40·5	+1·97	234 39·47	234 40·79	+1·32	289	3 23 11·5	+141·3363	0·0908	141·4271	3638·767	3638·83	+0·063
	291	3 30 13	234 40·5	+2·33	234 39·83	234 41·36	+1·53	290	3 26 38·5	−141·3434	0·0950	141·4384	3639·057	3640·40	+1·343
	292	3 32 55·5	234 40·5	+2·46	234 39·96	234 41·53	+1·57	293	3 35 4	−141·4586	0·1069	141·5655	3642·328	3644·19	+1·862
	295	3 43 53·5	234 43·0	+3·14	234 43·14	234 42·27	−0·87	294	3 40 0	+141·5471	0·1152	141·6623	3644·818	3646·39	+1·572
App. index corr. −1·6476							+0·89								+1·210
XLIV. Juno & θ November 19, 1874	296	19 43 31	235 30·0	+0·21	235 27·21	235 29·62	+2·41	297	19 45 14	+157·5561	0·1030	157·6591	4056·398	4055·68	−0·718
	299	19 52 39	235 31·5	+0·17	235 28·67	235 30·17	+1·50	298	19 49 10	−157·6308	0·0994	157·7302	4058·228	4057·44	−0·788
	300	19 53 44	235 31·0	+0·16	235 28·16	235 30·25	+2·09	301	19 55 58	−157·6909	0·0938	157·7847	4059·631	4060·50	+0·869
	303	20 2 22	235 32·5	+0·13	235 29·63	235 30·79	+1·16	302	19 59 7	+157·7851	0·0914	157·8765	4061·992	4061·91	−0·082
App. index corr. −1·6355							+1·79								−0·180
XLV. Juno & μ November 19, 1874	304	20 11 26	66 43·0	−0·08	66 39·92	66 37·15	−2·77	305	20 12 50	+141·8287	0·0724	141·9011	3650·962	3647·01	−3·952
	307	20 19 58	66 41·5	−0·08	66 38·42	66 37·25	−1·17	306	20 16 51	−141·7605	0·0703	141·8308	3649·154	3645·18	−3·974
	308	20 22 42	66 40·0	−0·08	66 36·92	66 37·29	+0·37	309	20 24 42	−141·6599	0·0665	141·7264	3646·468	3641·61	−4·858
	311	20 32 28	66 42·5	−0·09	66 39·41	66 37·39	−2·02	310	20 28 49	+141·5682	0·0646	141·6328	3644·059	3639·70	−4·359
App. index corr. −1·6355							−1·40								−4·286
XLVI. Juno & μ November 19, 1874	312	20 38 58	66 43·0	−0·09	66 39·91	66 37·45	−2·46	313	20 40 45	+141·3303	0·0598	141·3901	3637·815	3634·22	−3·595
	315	20 47 44	66 42·0	−0·09	66 38·91	66 37·54	−1·37	314	20 44 51	−141·2650	0·0583	141·3233	3636·096	3632·33	−3·766
	316	20 50 11	66 42·5	−0·09	66 39·41	66 37·56	−1·85	317	20 51 31	−141·1781	0·0562	141·2343	3633·807	3629·26	−4·547
	319	20 57 31	66 44·0	−0·09	66 40·91	66 37·65	−3·26	318	20 55 0	+141·1178	0·0551	141·1729	3632·227	3627·65	−4·577
App. index corr. −1·6355							−2·24								−4·121
XLVII. Juno & θ November 19, 1874	320	21 2 43	235 36·5	−0·01	235 33·49	235 34·72	+1·23	321	21 4 8	+158·9607	0·0609	159·0216	4091·455	4091·34	−0·115
	323	21 11 49	235 36·0	−0·02	235 32·98	235 35·30	+2·32	322	21 9 25	−159·0344	0·0594	159·0938	4093·313	4093·75	+0·437
	324	21 13 2	235 36·5	−0·02	235 33·48	235 35·41	+1·93	325	21 14 15	−159·1721	0·0582	159·2303	4096·825	4095·97	−0·855
	327	21 21 6	235 37·0	−0·03	235 33·97	235 35·94	+1·97	326	21 17 40	+159·2097	0·0574	159·2671	4097·772	4097·52	−0·252
App. index corr. −1·6355							+1·86								−0·196
XLVIII. Juno & ι November 20, 1874	328	19 14 16	281 6·0	−1·16	281 1·84	281 2·08	+0·24	329	19 17 0	+151·4131	0·1114	151·5245	3898·563	3902·44	+3·877
	331	19 25 3	281 1·5	−0·98	280 57·52	280 59·79	+2·27	330	19 19 35	−151·4631	0·1083	151·5714	3899·769	3903·38	+3·611
	332	19 27 27	281 3·0	−0·94	280 59·06	280 59·26	+0·20	333	19 28 33	−151·5857	0·0983	151·6840	3902·667	3906·61	+3·943
	335	19 37 6	280 59·0	−0·81	280 55·19	280 57·12	+1·93	334	19 32 35	+151·6567	0·0944	151·7511	3904·393	3908·06	+3·667
App. index corr. −1·8850							+1·16								+3·775

No. of group — Name of objects — Data	Position Angles							Distances							
	Rotation number	Greenwich sidereal time	Observed position angle	Refraction	Obs. pos. ang. = mean + app. index correction	Computed position angle	C–O and mean	Rotation number	Greenwich sidereal time	Sc. A–Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Observed dist. in arc	Computed dist.	C–O and mean
		h. m. sec.							h. m. sec.	rev.	rev.	rev.			
XLIX. Juno & ν November 20, 1874	336	19 43 24	76° 25′·0	−0′·28	76° 21′·72	76° 20′·86	−0′·86	337	19 45 54	+185·5323	0·1158	185·6481	4776″·526	4772″·72	−3″·806
	339	19 55 37	76 25·5	−0·25	76 22·25	76 21·54	−0·71	338*	19 51 46	−185·0907	0·1097	185·2005	4765·010	4770·19	[+5·180]
	340	19 59 58	76 25·5	−0·24	76 22·26	76 21·78	−0·48	341*	20 3 37	−185·2156	0·0992	185·3148	4767·951	4765·01	−2·941
	343	20 13 38	76 27·0	−0·21	76 23·79	76 22·52	−1·27	342	20 8 18	+185·1270	0·0955	185·2225	4765·575	4762·97	−2·605
App. index corr. −1·8850							−0·83								−3·073
L. Juno & ι November 20, 1874	344	2 12 20	279 40·0	+0·33	279 37·33	279 34·18	−3·15	345	2 14 55	+157·4852	0·0935	157·5787	4054·330	4057·67	+3·340
	347	2 29 4	279 35·0	+0·40	279 32·40	279 30·90	−1·50	346	2 19 10	−157·5989	0·0973	157·6962	4057·353	4059·23	+1·877
	348	2 32 18	279 34·0	+0·41	279 31·41	279 30·26	−1·15	349	2 34 32	−157·7643	0·1136	157·8779	4062·028	4064·84	+2·812
	351	2 42 48	279 34·0	+0·47	279 31·47	279 28·22	−3·25	350	2 39 17	+157·8091	0·1198	157·9289	4063·341	4066·58	+3·239
App. index corr. −1·8850							−2·26								+2·817
LI. Juno & ν November 20, 1874	352	2 48 11	76 49·0	+1·15	76 47·15	76 43·48	−3·67	353	2 49 56	+178·2821	0·1297	178·4118	4590·343	4587·09	−3·253
	355	3 7 43	76 48·5	+1·60	76 47·10	76 44·54	−2·56	354	2 54 7	−178·1650	0·1362	178·3012	4587·498	4585·31	−2·188
	356	3 9 35	76 48·0	+1·66	76 46·66	76 44·63	−2·03	357	3 10 41	−177·8753	0·1694	178·0447	4580·898	4578·31	−2·588
	359	3 22 4	76 50·0	+2·11	76 49·11	76 45·34	−3·77	358	3 14 59	+177·7853	0·1806	177·9659	4578·872	4576·51	−2·362
App index corr. −1·8850							−3·01								−2·598
LII. Juno & ι November 23, 1874	360	19 30 27	271 2·5	−0·71	270 58·79	270 59·56	+0·77	361	19 32 10	+210·1400	0·1440	210·2840	5410·381	5412·95	+2·569
	363	19 39 8	271 2·0	−0·62	270 58·38	270 58·81	+0·43	362	19 36 10	−210·1610	0·1383	210·2993	5410·774	5414·37	+3·596
	364	19 40 26	271 2·0	−0·61	270 58·39	270 58·71	+0·32	365	19 41 59	−210·2443	0·1305	210·3748	5412·718	5416·49	+3·772
	367	19 48 39	271 0·5	−0·55	270 56·95	270 57·99	+1·04	366	19 45 37	+210·3524	0·1260	210·4784	5415·383	5417·91	+2·527
App. index corr. −1·8884							+0·64								+3·116
LIII. Juno & χ November 23, 1874	368	19 52 34	87 31·5	−0·44	87 28·06	87 26·81	−1·25	369	19 54 26	+168·7368	0·0914	168·8282	4343·768	4344·04	+0·272
	371	20 0 25	87 33·0	−0·40	87 29·60	87 27·47	−2·13	370	19 58 9	−168·6877	0·0886	168·7763	4342·432	4342·65	+0·218
	372	20 4 24	87 33·0	−0·38	87 29·62	87 27·83	−1·79	373	20 6 7	−168·6148	0·0831	168·6979	4340·415	4339·62	−0·795
	375	20 16 35	87 33·0	−0·33	87 29·67	87 28·91	−0·76	374	20 12 9	+168·5074	0·0793	168·5867	4337·554	4337·34	−0·214
App. index corr. −1·8884							−1·48								−0·130
LIV. Juno & χ November 23, 1874	376	20 20 51	87 32·5	−0·31	87 29·19	87 29·29	+0·10	377	20 22 41	+168·3643	0·0737	168·4380	4333·728	4333·36	−0·368
	379	20 29 48	87 35·5	−0·28	87 32·22	87 29·97	−2·25	378	20 27 18	−168·2837	0·0715	168·3552	4331·598	4331·59	−0·008
	380	20 36 4	87 35·5	−0·26	87 32·24	87 30·64	−1·60	381	20 37 22	−168·1571	0·0672	168·2243	4328·230	4327·76	−0·470
	383	20 47 1	87 36·0	−0·23	87 32·77	87 31·59	−1·18	382	20 44 6	+168·0547	0·0646	168·1193	4325·528	4325·19	−0·338
App. index corr. −1·8884							−1·23								−0·296
LV. Juno & ι November 23, 1874	384	20 54 22	270 54·5	−0·24	270 51·26	270 52·43	+1·17	385	20 55 39	+211·3884	0·0775	211·4659	5440·790	5443·99	+3·200
	387	21 3 5	270 54·5	−0·22	270 51·28	270 51·63	+0·35	386	21 0 35	−211·5190	0·0757	211·5947	5444·104	5445·85	+1·746
	388	21 5 39	270 54·0	−0·21	270 50·79	270 51·49	+0·70	389	21 6 50	−211·5641	0·0735	211·6376	5445·208	5448·19	+2·982
	391	21 12 41	270 53·0	−0·19	270 49·81	270 50·89	+1·08	390	21 9 49	+211·5928	0·0726	211·6654	5445·923	5449·32	+3·397
App. index corr. −1·8884							+0·85								+2·831
LVI. Juno & ι November 24, 1874	384 bis	1 48 43	268 58·0	+0·37	268 55·37	268 53·87	−1·50	385 bis	1 53 31	+234·8241	0·1107	234·9348	6044·620	6044·87	+0·250
	387 „	2 2 56	268 55·5	+0·45	268 52·95	268 53·10	+0·15	386 „	1 58 13	−234·8465	0·1148	234·9613	6045·301	6046·55	+1·249
	387 „	2 2 56	268 55·5	+0·45	268 52·95	268 53·10	+0·15	388 „	2 4 42	−234·9206	0·1208	235·0414	6047·362	6048·88	+1·518
	390 „	2 22 28	268 55·5	+0·58	268 53·08	268 52·04	−1·04	389 „	2 9 6	+235·0312	0·1253	235·1565	6050·323	6050·47	+0·147
App. index corr. −1·8816							−0·56								+0·791

* The observation 338 has been rejected, and 341 used twice instead. It seems probable that the handle has been touched before reading scale.

No. of group — Name of objects — Date	Position Angles: Rotation number	Greenwich sidereal time	Observed position angle	Refraction	Obs. pos. ang. = mean + app. index correction	Computed position angle	C–O and mean	Distances: Rotation number	Greenwich sidereal time	Sc. A – Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Observed dist. in arc	Computed dist.	C–O and mean
		h. m. sec.	° ′	′	° ′	° ′	′		h. m. sec.	rev.	rev.	rev.	″	″	″
LVII. Juno & χ November 24, 1874	391 bis	2 25 23	90 23·0	+0·62	90 20·62	90 16·10	−4·52	392	2 29 3	+143·8541	0·0984	143·9525	3703·742	3703·40	−0·342
	394	2 52 25	90 24·0	+0·92	90 21·92	90 18·72	−3·20	393	2 48 55	−143·6144	0·1234	143·7378	3698·219	3696·41	−1·809
	394	2 52 25	90 24·0	+0·92	90 21·92	90 18·72	−3·20	395	2 54 26	−143·4991	0·1323	143·6314	3695·481	3694·49	−0·991
	397	3 5 58	90 26·25	+1·15	90 24·40	90 20·00	−4·40	396	3 3 33	+143·3421	0·1484	143·4905	3691·856	3691·32	−0·536
App. index corr. −1·8816							−3·83								−0·920
LVIII. Juno & χ November 24, 1874	398	3 10 23	90 27·0	+1·24	90 25·24	90 20·43	−4·81	399	3 12 16	+143·1769	0·1707	143·3476	3688·180	3688·28	+0·100
	401	3 19 32	90 27·0	+1·47	90 25·47	90 21·30	−4·17	400	3 15 21	−143·1564	0·1791	143·3355	3687·869	3687·20	−0·669
	401	3 19 32	90 27·0	+1·47	90 25·47	90 21·30	−4·17	402	3 20 45	−143·0668	0·1958	143·2626	3685·993	3685·36	−0·633
	404	3 26 13	90 28·0	+1·63	90 26·63	90 21·96	−4·67	403	3 23 51	+143·0129	0·2066	143·2195	3684·883	3684·27	−0·613
App. index corr. −1·8816							−4·45								−0·454
LIX. Juno & ι November 24, 1874	405	3 29 1	268 51·0	+1·68	268 49·68	268 48·47	−1·21	406	3 31 3	+235·9143	0·3464	236·2607	6078·734	6079·32	+0·586
	408	3 38 9	268 49·0	+2·03	268 48·03	268 48·02	−0·01	407	3 34 36	−235·9298	0·3694	236·2992	6079·724	6080·53	+0·806
	...	...	...	...	...	...	...	409	3 39 36	−235·9642	0·4062	236·3704	6081·556	6082·26	+0·704
	...	...	...	...	...	...	...	406*	3 31 3	+235·9143	0·3464	236·2607	6078·734	6079·32	+0·586
App. index corr. −1·8816							−0·61								+0·671
LX. Juno & μ November 25, 1874	405 bis	19 34 11	50 0·0	+0·36	49 57·36	49 28·81	−28·55	406 bis	19 36 47	+13·4027	0·0087	13·4114	345·061	346·59	+1·529
	408 „	19 47 48	49 18·0	+0·27	49 15·27	49 8·06	−7·21	407 „	19 44 33	−13·3420	0·0080	13·3500	343·481	344·08	+0·599
	409 „	19 49 9	49 14·0	+0·26	49 11·26	49 5·98	−5·28	410	19 50 53	−13·2633	0·0075	13·2708	341·444	342·02	+0·576
	412	19 59 17	49 22·5	+0·21	49 19·71	48 50·38	−29·33	411	19 54 9	+13·1969	0·0073	13·2042	339·730	340·96	+1·230
App. index corr. −1·8816							−17·59								+0·984
LXI. Juno & μ November 25, 1874	413	20 3 31	49 16·0	+0·20	49 13·20	48 43·38	−29·82	414	20 5 2	+13·0783	0·0067	13·0850	336·663	337·45	+0·787
	416	20 11 56	48 42·0	+0·16	48 39·16	48 29·83	−9·33	415	20 7 40	−13·0276	0·0065	13·0341	335·353	336·60	+1·247
	417	20 14 46	48 37·0	+0·15	48 34·15	48 25·19	−8·96	418	20 16 42	−12·9219	0·0061	12·9280	332·624	333·68	+1·056
	420	20 23 12	48 43·0†	+0·12	48 40·12	48 11·21	−28·91	419	20 20 12	+12·9056	0·0060	12·9116	332·201	332·51	+0·309
App. index corr. −1·8816							−19·26								+0·850
LXII. Juno & μ November 25, 1874	421	20 27 23	48 34·5	+0·11	48 31·61	48 4·09	−27·52	422	20 28 53	+12·7774	0·0056	12·7830	328·893	329·71	+0·817
	424	20 36 24	48 0·0	+0·08	47 57·08	47 48·66	−8·42	423	20 33 51	−12·7151	0·0054	12·7205	327·285	328·10	+0·815
	425	20 37 30	47 56·5	+0·08	47 53·58	47 46·85	−6·73	426	20 38 49	−12·6485	0·0052	12·6537	325·566	326·52	+0·954
	428	20 44 46	48 7·0	+0·06	48 4·06	47 33·84	−30·22	427	20 41 21	+12·6255	0·0051	12·6306	324·971	325·70	+0·729
App. index corr. −1·8816							−18·22								+0·829
LXIII. Juno & μ November 25, 1874	429	20 49 31	47 54·0	+0·05	47 51·05	47 25·37	−25·68	430	20 52 22	+12·4710	0·0048	12·4758	320·989	322·14	+1·151
	432	20 57 57	47 25·5	+0·04	47 22·54	47 10·24	−12·30	431	20 55 27	−12·4455	0·0047	12·4502	320·330	321·16	+0·830
	433	20 59 53	47 19·0	+0·04	47 16·04	47 6·72	−9·32	434	21 0 41	−12·3777	0·0046	12·3823	318·583	319·48	+0·897
	436	21 6 1	47 27·5	+0·03	47 24·53	46 55·41	−29·12	435	21 3 50	+12·3554	0·0045	12·3599	318·006	318·45	+0·444
App. index corr. −1·8816							−19·11								+0·831
LXIV. Juno & μ November 25, 1874	437	1 57 39	34 42·5	+0·28	34 39·78	34 3·18	−36·60	438	1 59 22	+8·8724	0·0025	8·8749	228·341	230·02	+1·679
	440	2 5 57	33 42·5	+0·31	33 39·81	33 38·14	−1·67	439	2 2 58	−8·8455	0·0025	8·8480	227·649	229·08	+1·431
	441	2 7 47	33 42·5	+0·32	33 39·82	33 31·18	−8·64	442	2 9 28	−8·7681	0·0025	8·7706	225·657	227·37	+1·713
	444	2 16 7	33 38·0	+0·36	33 35·36	33 0·97	−34·39	443	2 12 45	+8·7623	0·0025	8·7648	225·509	226·54	+1·031
App. index corr. −1·8889							−20.32								+1·464

* This observation being wanting in the original, 406 is repeated in the calculation.

† Original obs. 48° 33′·0.

No. of group — Name of objects — Date	Position Angles							Distances							
	Rotation number	Greenwich sidereal time	Observed position angle	Refraction	Obs. pos. ang. = mean + app. index correction	Computed position angle	C–O and mean	Rotation number	Greenwich sidereal time	Sc. A – Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Observed dist. in arc	Computed dist.	C–O and mean
		h. m. sec.	° ′	′	° ′	° ′	′		h. m. sec.	rev.	rev.	rev.	″	″	″
LXV.	445	2 18 53	33 24·0	+0·37	33 21·37	32 50·86	−30·51	446	2 21 17	+ 8·6619	0·0025	8·6644	222·925	224·32	+1·395
Juno & μ	448	2 27 54	32 37·5	+0·42	32 34·92	32 17·56	−17·36	447	2 25 8	− 8·6270	0·0025	8·6295	222·027	223·32	+1·293
November 25, 1874	449	2 29 9	32 28·5	+0·43	32 25·93	32 12·93	−13·00	450	2 30 45	− 8·5903	0·0025	8·5928	221·083	221·92	+0·837
	445	2 18 53	33 24·0	+0·37	33 21·37	32 50·86	−30·51	451	2 34 19	+ 8·5411	0·0025	8·5436	219·818	221·01	+1·192
App. index corr. = 1·8889							−22·85								+1·179
LXVI.	452	2 43 20	32 0·0	+0·51	31 57·51	31 18·83	−38·68	453	2 46 38	+ 8·4189	0·0025	8·4214	216·673	217·93	+1·257
Juno & μ	455	2 53 4	30 53·5	+0·58	30 51·08	30 40·98	−10·10	454	2 49 27	− 8·3964	0·0025	8·3989	216·094	217·24	+1·146
November 25, 1874	455 bis	2 55 46	30 46·0	+0·61	30 43·61	30 30·39	−13·22	456	2 57 9	− 8·3227	0·0024	8·3251	214·195	215·33	+1·135
	458	3 10 13	29 53·5	+0·73	29 51·23	29 32·82	−18·41	457	3 0 41	+ 8·2704	0·0024	8·2728	212·850	214·49	+1·640
App. index corr. = 1·8889							−20·10								+1·295
LXVII.*	459	3 19 47	30 20·0	+0·84	30 17·84	28 54·29	−23·55	460	3 20 57	− 8·0635	0·0024	8·0659	207·527	209·73	+2·203
Juno & μ	462	3 27 37	29 7·0	+0·94	29 4·94	28 21·56	−43·38	461	3 24 2	+ 8·0579	0·0024	8·0603	207·383	208·95	+1·567
November 25, 1874	463	3 31 33	28 46·5	+1·00	28 44·50	28 4·33	−43·38	...	...	...	...	...	...	...	...
	459	3 19 47	30 20·0	+0·84	30 17·84	28 54·29	−23·55	...	...	...	...	...	...	...	...
App. index corr. = 1·8889							...								+1·885
LXVIII.	464	19 38 55	297 43·5	−0·79	297 39·71	298 0·55	+20·84	465	19 40 21	+ 8·4806	0·0037	8·4843	218·292	219·92	+1·628
Juno & μ	467	19 45 47	297 12·0	−0·71	297 8·29	297 36·39	+28·10	466	19 43 15	− 8·5257	0·0037	8·5294	219·452	220·65	+1·198
November 26, 1874	468	19 47 37	297 7·0	−0·69	297 3·31	297 29·90	+26·59	469	19 48 44	− 8·5858	0·0036	8·5894	220·996	222·07	+1·074
	471	19 53 44	596 49·5	−0·63	296 45·87	297 8·99	+23·12	470	19 50 54	+ 8·6049	0·0035	8·6084	221·484	222·63	+1·146
App. index corr. = 1·8819							+23·91								+1·262
LXIX.	472	19 56 21	296 32·0	−0·60	296 28·40	296 59·99	+31·59	473	19 57 35	+ 8·6803	0·0034	8·6837	223·422	224·37	+0·948
Juno & μ	475	20 2 45	296 24·0	−0·55	296 20·45	296 38·35	+17·90	474	20 0 20	− 8·7163	0·0034	8·7197	224·349	225·10	+0·751
November 26, 1874	476	20 4 20	296 17·0	−0·54	296 13·46	296 32·99	+19·53	477	20 5 32	− 8·7743	0·0033	8·7776	225·838	226·46	+0·622
	479	20 11 34	295 41·5	−0·48	295 38·02	296 9·16	+31·14	478	20 8 8	+ 8·7976	0·0033	8·8009	226·437	227·14	+0·703
App. index corr. = 1·8819							+25·04								+0·756
LXX.	480	20 14 4	295 31·0	−0·47	295 27·53	296 0·99	+33·46	481	20 15 39	+ 8·8679	0·0032	8·8711	228·243	229·15	+0·907
Juno & μ	483	20 21 16	295 22·0	−0·42	295 18·58	295 37·55	+18·97	482	20 17 45	− 8·8565	0·0032	8·8597	227·951	229·70	+1·749
November 26, 1874	484	20 25 4	295 10·5	−0·40	295 7·10	295 25·36	+18·26	485	20 26 16	− 8·9834	0·0031	8·9865	231·212	231·98	+0·768
	487	20 51 45	293 31·5	−0·26	293 28·24	294 2·80	+34·56	486	20 28 26	+ 9·0050	0·0031	9·0081	231·768	232·57	+0·802
App. index corr. = 1·8819							+26·31								+1·057
LXXI.	488	2 1 50	282 35·0	+0·25	282 32·25	282 58·82	+26·57	489	2 3 47	+12·8757	0·0073	12·8830	331·465	332·39	+0·925
Juno & μ	491	2 10 24	282 35·5	+0·28	282 32·78	282 46·29	+13·51	490	2 7 15	−12·9273	0·0076	12·9349	332·801	333·48	+0·679
November 26, 1874	492	2 13 1	282 23·5	+0·29	282 20·79	282 42·31	+21·52	493	2 15 11	−13·0092	0·0082	13·0174	334·923	335·90	+0·977
	495	2 23 25	282 10·0	+0·33	282 7·33	282 27·76	+20·43	494	2 20 14	+13·0978	0·0087	13·1065	337·216	337·41	+0·194
App. index corr. = 1·8769							+20·51								+0·694
LXXII.	496	2 50 52	281 29·5	+0·47	281 26·97	281 50·09	+23·12	497	2 52 52	+13·4816	0·0129	13·4945	347·199	347·32	+0·121
Juno & μ	499	2 58 48	281 27·5	+0·53	281 25·03	281 39·60	+14·57	498	2 55 22	−13·5172	0·0134	13·5306	348·127	348·10	−0·027
November 26, 1874	499	2 58 48	281 27·5	+0·53	281 25·03	281 39·60	+14·57	500	3 3 53	−13·6280	0·0151	13·6431	351·023	350·65	−0·373
	502	3 9 22	281 10·5	+0·63	281 8·13	281 26·01	+17·88	501	3 6 35	+13·6251	0·0158	13·6409	350·966	351·49	+0·524
App. index corr. = 1·8769							+17·53								+0·061

* Group LXVII. very low ; cloud : not to be used.

No. of group — Name of objects — Date	Position Angles: Rotation number	Greenwich sidereal time	Observed position angle	Refraction	Obs. pos. ang. = mean + app. index correction	Computed position angle	C–O and mean	Distances: Rotation number	Greenwich sidereal time	Sc. A – Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Observed dist. in arc	Computed dist.	C–O and mean
		h. m. sec.							h. m. sec.	rev.	rev.	rev.			
LXXIII. Juno & μ November 26, 1874	503	3 12 2	281° 7′·0	+0′·66	281° 4′·66	281° 22′·63	+17′·97	504	3 13 14	+13·7121	0·0175	13·7296	353″·248	353″·47	+0″·222
	506	3 19 7	281 1·5	+0·75	280 59·25	281 13·68	+14·43	505	3 16 49	−13·7435	0·0187	13·7622	354·087	354·55	+0·463
	506 bis	3 20 0	280 58·5	+0·76	280 56·26	281 12·67	+16·41	507	3 21 59	−13·8114	0·0204	13·8318	355·877	356·12	+0·243
	509	3 28 17	280 35·5	+0·90	280 33·40	281 2·47	+29·07	508	3 24 22	+13·8483	0·0213	13·8696	356·850	356·83	−0·020
App. index corr. −1·8769							+19·47								+0·227
LXXIV. Juno & μ November 26, 1874	510	3 30 5	280 49·0	+0·93	280 46·93	281 0·17	+13·24	Distances were not observed							
	511	3 33 0	280 31·0	+1·00	280 29·00	280 56·62	+27·62								
	512	3 36 50	280 40·0	+1·08	280 38·08	280 51·95	+13·87								
	513	3 39 39	280 26·5	+1·15	280 24·65	280 48·48	+23·83								
App. index corr. ...							+19·64								...
LXXV. Juno & μ November 27, 1874	510 bis	19 38 7	270 21·5	−0·58	270 17·92	270 24·21	Wrong star observed	511 bis	19 54 47	...	0·0132	...	...	635·64	Wrong star observed
	513 „	20 0 2	271 4·0	−0·44	271 0·56	270 16·51		512 „	19 57 18	...	0·0129	...	...	636·47	
	514	20 2 12	270 58·5	−0·43	270 55·07	270 15·73		515	20 3 18	...	0·0124	...	...	638·38	
	517	20 9 53	271 18·0	−0·39	271 14·61	270 13·04		516	20 6 48	...	0·0121	...	...	639·49	
App. index corr. ...															...
LXXVI. Juno & μ November 28, 1874	518	2 41 45	265 47·0	+0·89	265 44·89	265 41·60	−3·29	519	2 42 56	+45·9756	0·0350	46·0106	1183·803	1181·26	−2·543
	521	2 49 5	265 26·5	+1·00	265 24·50	265 41·32	+16·82	520	2 46 11	−46·0263	0·0363	46·0626	1185·142	1182·24	−2·902
	522	2 50 54	265 26·5	+1·03	265 24·53	265 41·27	+16·74	523	2 53 57	−46·0850	0·0401	46·1251	1186·749	1184·53	−2·219
	525	3 8 36	265 47·0	+1·38	265 45·38	265 40·48	−4·90	524	3 4 24	+46·2141	0·0463	46·2604	1190·231	1187·66	−2·571
App. index corr. −1·8991							+6·34								−2·559
LXXVII. Juno & ν November 29, 1874	526	2 8 25	126 15·5	−0·17	126 12·33	125 17·78	−54·55	527	2 10 43	+13·0983	0·0080	13·1063	337·211	338·08	+0·869
	529	2 16 7	126 12·0	−0·21	126 8·79	125 32·04	−36·75	528	2 14 7	−13·0769	0·0082	13·0851	336·665	337·34	+0·675
	530	2 17 31	126 12·0	−0·22	126 8·78	125 34·66	−34·12	531	2 19 20	−13·0462	0·0086	13·0548	335·886	336·59	+0·704
	533	2 31 22	126 57·0	−0·32	126 53·68	126 0·62	−53·06	532	2 22 56	+12·9938	0·0088	13·0026	334·543	336·19	+1·647
App. index corr. −1·8585							−44·62								+0·974
LXXVIII. Juno & ν November 29, 1874	534	2 34 25	127 18·0*	−0·34	127 14·66	126 6·36	−68·30	535	2 36 29	+12·8969	0·0100	12·9069	332·081	332·46	+0·379
	537	2 43 41	127 3·5	−0·43	127 0·07	126 23·91	−36·16	536	2 40 10	−12·8468	0·0104	12·8572	330·802	331·68	+0·878
	538	2 45 34	127 5·0	−0·45	127 1·55	126 27·62	−33·93	539	2 47 33	−12·7829	0·0113	12·7942	329·181	330·09	+0·909
	541	2 54 22	127 51·0	−0·56	127 47·44	126 44·62	−62·82	540	2 50 29	+12·8008	0·0116	12·8124	329·649	329·47	−0·179
App. index corr. −1·8585							−50·30								+0·497
LXXIX. Juno & ν November 29, 1874	542	2 57 22	127 57·0	−0·61	127 53·39	126 50·36	−63·03	544	2 59 27	+12·7099	0·0130	12·7229	327·347	327·57	+0·223
	546	3 6 44	127 48·0	−0·76	127 44·24	127 8·36	−35·88	545	3 2 35	−12·6770	0·0135	12·6905	326·513	326·91	+0·397
	547	3 10 7	127 55·0	−0·83	127 51·17	127 14·91	−36·26	548	3 12 7	−12·5887	0·0160	12·6047	324·305	324·92	+0·615
	550	3 21 52	127 52·0	−1·12	127 47·88	127 37·91	−69·97	549	3 17 38	+12·5134	0·0168	12·5302	322·388	323·77	+1·382
App. index corr. −1·8585							−51·28								+0·654
LXXX. Juno & ν November 30, 1874	551	20 30 17	179 57·5	+0·15	179 54·65	179 11·25	−43·40	552	20 35 48	−8·4805	0·0025	8·4830	218·258	215·44	−2·818
	554	20 45 4	181 38·5	+0·13	181 35·63	180 17·13	−78·50	553	20 38 34	+8·5170	0·0025	8·5195	219·197	215·46	−3·737
	555	20 47 25	181 41·5	+0·12	181 38·62	180 27·44	−71·18	556	20 48 34	+8·4989	0·0025	8·5014	218·731	215·60	−3·131
	558	20 54 22	181 48·5	+0·11	181 45·61	180 58·03	−47·58	557	20 51 26	−8·5035	0·0025	8·5060	218·849	215·66	−3·189
App. index corr. −1·8619							−60·17								−3·219

* Original obs. 128° 18′·0.

No. of group — Name of objects — Date	Position Angles							Distances							
	Rotation number	Greenwich sidereal time	Observed position angle	Refraction	Obs. pos. ang. = mean + app. index correction	Computed position angle	C–O and mean	Rotation number	Greenwich sidereal time	Sc. A – Sc. B + approx. index correction	Refraction	Resulting dist. in screw revolutions	Observed dist. in arc	Computed dist.	C–O and mean
		h. m. sec.							h. m. sec.	rev.	rev.	rev.			
LXXXI.	559	20 56 0	181° 36′·5	+0′·11	181° 33′·61	181° 5′·47	−28′·14	560	20 57 5	−8·5213	0·0025	8·5238	219″·308	215″·76	−3″·548
Juno & ν	562	21 2 53	182 50·0	+0·10	182 47·10	181 36·01	−71·09	561	20 59 59	+8·5249	0·0025	8·5274	219·400	215·80	−3·600
November 30, 1874	563	21 4 19	182 56·5	+0·10	182 53·60	181 42·34	−71·26	564	21 5 33	+8·4850	0·0025	8·4875	218·374	215·93	−2·444
	566	21 11 17	182 58·5	+0·09	182 55·59	182 13·47	−42·12	565	21 8 56	−8·5030	0·0025	8·5055	218·837	216·01	−2·827
App. index corr. −1·8619							−53′·15								−3″·105

CHAPTER X.

FORMATION OF THE EQUATIONS OF CONDITION.

If the position of a star of comparison is supposed to be absolutely determined, the tabular motion of the planet to be accurately known, and the tabular place affected with a small constant error in $\mathcal{A}$R and Declination, then each observed distance

= computed distance + error of planet in $\mathcal{A}$R × corresponding factor
+ error of planet in declination × corresponding factor
+ number of *percent.* of error of adopted parallax × corresponding factor.

Putting o = the observed quantity,
c = the computed quantity,
and adopting the same notation as in the last chapter, we have from each measure of distance—

$$c + f' \Delta\alpha + f'' \Delta\delta + f''' \Delta\pi = o.$$

But if the scale value, from displacement of focus, temperature, or any other cause, is different from the value we have assumed in the calculations, the correction of o will be proportional to the distance measured, and may be expressed by nz, where z being small, n may conveniently be taken with 1000″ seconds of arc as unit, and z = the error of adopted scale value in 1000″.

The complete expression derived from each observation of distance will then be

$$c + f' \Delta\alpha + f'' \Delta\delta + f''' \Delta\pi = o + nz.$$

To eliminate z a second star must be employed, which should be as nearly as possible at an equal distance from the planet as the first star, and opposite to it.

If the positions of both stars are absolutely determined, we should then have two equations of the above type, in which the factors f', f'', and f''' would be nearly equal and with opposite signs.

The morning equations give two similar equations, but the scale cannot be assumed the same as in the evening observations—that is, z must be taken different; say, $= z'$.

Similarly each observation of position angles gives an equation of the form

$$c + f_{I} \Delta\alpha + f_{II} \Delta\delta + f_{III} \Delta\pi = o + \begin{matrix} E \\ \text{or} \\ W \end{matrix},$$

where E is the outstanding correction of the position circle-readings for evening observations—that is, for stars E. of the meridian—and W the same correction for stars W. of the meridian—that is, for morning observations.

The following tables contain the equations resulting from all the observations that are symmetrical and nearly complete. The observations on the 10th and 11th are not included because made with a low power, and because in these it was unsuccessfully attempted to measure simultaneously the position angle and the distance.

The equations from the distances have the type—

From evening observations $f' \Delta\alpha + f'' \Delta\delta + f''' \Delta\pi - nz + (C-O) = 0.$
„ morning „ $f' \Delta\alpha + f'' \Delta\delta + f''' \Delta\pi - nz' + (C-O) = 0.$

The equations from the position angles have the type—

From evening observations $f_{,} \Delta\alpha + f_{,,} \Delta\delta + f_{,,,} \Delta\pi - E + (C-O) = 0.$
„ morning „ $f_{,} \Delta\alpha + f_{,,} \Delta\delta + f_{,,,} \Delta\pi - W + (C-O) = 0.$

Each equation represents a *group* of observations, in which the factors are taken from Table VI.; $n = \frac{\text{distances in arc}}{1000}$, and C–O is taken from the last column in the table of results of observations.

Equations resulting from the Position Angles.

Juno compared with θ, November 12 and 13, 1874.

Evening Observations. Nov. 12.	X.	+ 0·925 Δα	− 3·702 Δδ	− 0·029 Δπ	− E	− 3′·70	= 0
	XI.	·918	3·770	·034	E	2·80	= 0
	XII.	·908	3·848	·039	E	1·06	= 0
	XIII.	·899	3·911	·045	E	2·18	= 0
Morning Observations. Nov. 12.	XIV.	+ 0·687 Δα	− 4·929 Δδ	− 0·150 Δπ	− W	− 0·91	= 0
	XV.	·642	5·071	·161	W	3·33	= 0
	XVI.	·597	5·197	·170	W	0·77	= 0
	XVII.	·554	5·314	·177	W	3·94	= 0
Evening Observations. Nov. 13.	XVIII.	− 6·422 Δα	− 8·271 Δδ	− 0·700 Δπ	− E	+ 24·18	= 0
	XIX.	6·836	8·109	·696	E	26·81	= 0
	XX.	7·215	7·920	·682	E	30·49	= 0
	XXI.	7·743	7·612	·647	E	30·59	= 0
Morning Observations. Nov. 13.	XXII.	− 10·034 Δα	− 1·302 Δδ	+ 0·577 Δπ	− W	+ 38·09	= 0
	XXIII.	9·844	0·793	·648	W	42·30	= 0
	XXIV.	9·480	0·075	·721	W	42·22	= 0
	XXV.	9·475	0·061	·723	W	36·10	= 0

Juno compared with ζ and λ, November 15, 1874.

ζ Evening Observations.	XXVIII.	+ 0·425 Δα	+ 0·591 Δδ	+ 0·038 Δπ	− E	− 1·95	= 0
	XXXI.	·419	·591	·027	E	1·98	= 0
λ Evening Observations.	XXIX.	− 0·275 Δα	− 0·776 Δδ	− 0·031 Δπ	− E	+ 2·22	= 0
	XXX.	·277	·778	·029	E	1·91	= 0
ζ Morning Observations.	XXXII.	+ 0·398 Δα	+ 0·595 Δδ	− 0·007 Δπ	− W	− 3·04	= 0
	XXXV.	·392	·596	·012	W	3·63	= 0
λ Morning Observations.	XXXIII.	− 0·308 Δα	− 0·789 Δδ	− 0·001 Δπ	− W	+ 0·35	= 0
	XXXIV.	·311	·789	·001	W	0·92	= 0

Equations resulting from the Distances.

Juno compared with θ, November 12 and 13, 1874.

Evening Observations. Nov. 12.	X.	0·9665 Δα	+	0·2433 Δδ	+	0·077 Δπ	−	0·908 z	−	4·675	= 0
	XI.	·9681		·2374		·072		·894		4·563	= 0
	XII.	·9697		·2306		·066		·877		4·106	= 0
	XIII.	·9709		·2255		·060		·864		3·887	= 0
Morning Observations. Nov. 12.	XIV.	0·9868 Δα	+	0·1390 Δα	−	0·044 Δπ	−	0·699 z'	−	4·773	= 0
	XV.	·9885		·1264		·054		·680		4·572	= 0
	XVI.	·9899		·1148		·062		·664		4·500	= 0
	XVII.	·9911		·1044		·067		·651		4·481	= 0
Evening Observations. Nov. 13.	XVIII.	0·7861 Δα	−	0·6142 Δδ	+	0·043 Δπ	−	0·332 z	−	3·090	= 0
	XIX.	·7616		·6448		·037		·328		3·316	= 0
	XX.	·7363		·6762		·033		·324		2·892	= 0
	XXI.	·6988		·7129		·024		·320		2·626	= 0
Morning Observations. Nov. 13.	XXII.	0·1300 Δα	−	0·9914 Δδ	−	0·032 Δπ	−	0·339 z'	−	0·069	= 0
	XXIII.	·0752		·9970		·030		·349		0·200	= 0
	XXIV.	·0087		·9998		·027		·362		0·021	= 0
	XXV.	·0069		1·0000		·026		·363		0·143	= 0

Juno compared with ζ and λ, November 15, 1874.

ζ Evening Observations.	XXVIII.	− 0·8069 Δα	+	0·5856 Δδ	−	0·032 Δπ	−	4·736 z	+	3·505	= 0
	XXXI.	·8106		·5805		·014		4·753		3·771	= 0
λ Evening Observations.	XXIX.	0·9389 Δα	−	0·3346 Δδ	+	0·038 Δπ	−	4·192 z	−	4·221	= 0
	XXX.	·9381		·3370		·031		4·182		4·303	= 0
ζ Morning Observations.	XXXII.	− 0·8258 Δα	+	0·5584 Δδ	+	0·055 Δπ	−	4·812 z'	+	4·129	= 0
	XXXV.	·8304		·5513		·073		4·833		3·815	= 0
λ Morning Observations.	XXXIII.	0·9276 Δα	−	0·3648 Δδ	−	0·063 Δπ	−	4·080 z'	−	4·564	= 0
	XXXIV.	·9267		·3674		·069		4·070		4·696	= 0

Equations resulting from the Position Angles.

Juno compared with θ and μ, November 18 and 19, 1874.

θ, Nov. 18. Morning Observations.	XL.	− 0·554 Δα	+	0·782 Δδ	+	0·048 Δπ	−	W	+	0′·33	= 0
	XLIII.	·546		·773		·060				0·89	= 0
μ, Nov. 18. Morning Observations.	XLI.	+ 0·339 Δα	−	0·770 Δδ	−	0·040 Δπ	−	W	−	3·23	= 0
	XLII.	·340		·773		·043		W		3·19	= 0
θ, Nov. 19. Evening Observations.	XLIV.	− 0·480 Δα	+	0·701 Δδ	−	0·012 Δπ	−	E	+	1·79	= 0
	XLVII.	·475		·695		·003		E		1·86	= 0
μ, Nov. 19. Evening Observations.	XLV.	+ 0·375 Δα	−	0·871 Δδ	−	0·000 Δπ	−	E	−	1·40	= 0
	XLVI.	·376		·874		·003		E		2·24	= 0

Equations resulting from the Position Angles.

Juno compared with ι and χ, November 23 and 24, 1874.

ι, Nov. 23. Evening Observations.	LII.	.	.	+ 0·011 Δα	+	0·638 Δδ	+	0·016 Δπ	−	E	+	0′·64	= 0
	LV.	.	.	·010		·634		·014				0·85	= 0
χ, Nov. 23. Evening Observations.	LIII.	.	.	+ 0·035 Δα	−	0·795 Δδ	−	0·016 Δπ	−	E	−	1·48	= 0
	LIV.	.	.	·035		·797		·016		E		1·23	= 0
ι, Nov. 24. Morning Observations.	LVI.	.	.	− 0·011 Δα	+	0·571 Δδ	+	0·013 Δπ	−	W	−	0·56	= 0
	LIX.	.	.	·012		·568		·015		W		0·61	= 0
χ, Nov 24. Morning Observations.	LVII.	.	.	− 0·005 Δα	−	0·935 Δδ	−	0·022 Δπ	−	W	−	3·83	= 0
	LVIII.	.	.	·006		·938		·023		W		4·45	= 0

Equations resulting from the Distances.

Juno compared with θ and μ, November 18 and 19, 1874.

θ, Nov. 18. Morning Observations.	XL.	.	.	− 0·8116 Δα	−	0·5798 Δδ	+	0·030 Δπ	−	3·597 z′	+	1″·229	= 0
	XLIII.	.	.	·8128		·5780		·044		3·641		1·210	= 0
μ, Nov. 18. Morning Observations.	XLI.	.	.	+ 0·9104 Δα	+	0·4038 Δδ	−	0·046 Δπ	−	4·108 z′	−	3·724	= 0
	XLII.	.	.	·9105		·4037		·052		4·094		4·032	= 0
θ, Nov. 19. Evening Observations.	XLIV.	.	.	− 0·8208 Δα	−	0·5664 Δδ	−	0·061 Δπ	−	4·059 z	−	0·180	= 0
	XLVII.	.	.	·8216		·5652		·043		4·095		0·196	= 0
μ, Nov. 19. Evening Observations.	XLV.	.	.	+ 0·9134 Δα	+	0·3698 Δδ	+	0·056 Δπ	−	3·648 z	−	4·286	= 0
	XLVI.	.	.	·9134		·3697		·049		3·635		4·121	= 0

Juno compared with ι and χ, November 23 and 24, 1874.

ι, Nov. 23. Evening Observations.	LII.	.	.	− 0·9949 Δα	+	0·0171 Δδ	−	0·061 Δπ	−	5·415 z	+	3′·116	= 0
	LV.	.	.	·9949		·0151		·038		5·444		2·831	= 0
χ, Nov. 23. Evening Observations.	LIII.	.	.	+ 0·9940 Δα	+	0·0443 Δδ	+	0·056 Δπ	−	4·342 z	−	0·130	= 0
	LIV.	.	.	·9941		·0435		·048		4·329		0·296	= 0
ι, Nov. 24. Morning Observations.	LVI.	.	.	− 0·9948 Δα	−	0·0195 Δδ	+	0·055 Δπ	−	6·046 z′	+	1·454	= 0
	LIX.	.	.	·9948		·0209		·072		6·080		1·326	= 0
χ, Nov. 24. Morning Observations.	LVII.	.	.	+ 0·9950 Δα	−	0·0054 Δδ	−	0·065 Δπ	−	3·697 z′	−	0·886	= 0
	LVIII.	.	.	·9948		·0062		·070		3·687		0·366	= 0

Equations resulting from the Position Angles.

Juno compared with μ, November 25 and 26, 1874.

Evening Observations. Nov. 25.	LX.	.	.	+ 6·556 Δα	−	7·618 Δδ	+	0·206 Δπ	−	E	−	17′·59	= 0
	LXI.	.	.	6·811		7·726		·181		E		19·26	= 0
	LXII.	.	.	7·056		7·823		·154		E		18·22	= 0
	LXIII.	.	.	7·032		7·912		·120		E		19·11	= 0
Morning Observations. Nov. 25.	LXIV.	.	.	+ 12·557 Δα	−	8·372 Δδ	−	0·897 Δπ	−	W	−	20·32	= 0
	LXV.	.	.	12·954		8·311		0·970		W		22·85	= 0
	LXVI.	.	.	13·729		8·131		1·106		W		20·10	= 0

Equations resulting from the Position Angles.

Juno compared with μ, November 25 and 26, 1874 (*continued*).

Evening Observations. Nov. 26.	LXVIII.	+ 7·183 $\Delta\alpha$	+ 13·831 $\Delta\delta$	+ 0·727 $\Delta\pi$	−	E	+	23·91	= 0
	LXIX.	6·809	13·674	·668		E		25·04	= 0
	LXX.	6·318	13·441	·591		E		26·31	= 0
Morning Observations. Nov. 26.	LXXI.	+ 2·262 $\Delta\alpha$	+ 10·064 $\Delta\delta$	+ 0·096 $\Delta\pi$	−	W	+	20·51	= 0
	LXXII.	1·987	9·683	·097		W		17·53	= 0
	LXXIII.	1·881	9·536	·101		W		19·47	= 0

Juno compared with ν, November 29 and 30, 1874.

Morning Observations. Nov. 29.	LXXVII.	− 5·950 $\Delta\alpha$	− 8·353 $\Delta\delta$	+ 0·162 $\Delta\pi$	−	W	−	44·62	= 0
	LXXVIII.	6·172	8·407	·200		W		50·30	= 0
	LXXIX.	6·387	8·454	·232		W		51·28	= 0
Evening Observations. Nov. 30.	LXXX.	− 15·948 $\Delta\alpha$	+ 0·063 $\Delta\delta$	− 0·665 $\Delta\pi$	−	E	−	60·17	= 0
	LXXXI.	15·917	·463	·569		E		53·15	= 0

Equations resulting from the Distances.

Juno compared with μ, November 25 and 26, 1874.

Evening Observations. Nov. 25.	LX.	+ 0·7527 $\Delta\alpha$	+ 0·6539 $\Delta\delta$	+ 0·059 $\Delta\pi$	−	0·343 z	+	0·984	= 0
	LXI.	·7448	·6629	·053		·334		0·850	= 0
	LXII.	·7373	·6714	·048		·328		0·829	= 0
	LXIII.	·7269	·6799	·043		·320		0·831	= 0
Morning Observations. Nov. 25.	LXIV.	+ 0·5508 $\Delta\alpha$	+ 0·8327 $\Delta\delta$	− 0·012 $\Delta\pi$	−	0·228 z'	+	1·464	= 0
	LXV.	·5315	·8453	·013		·221		1·179	= 0
	LXVI.	·5072	·8602	·013		·215		1·295	= 0
Evening Observations. Nov. 26.	LXVIII.	− 0·8815 $\Delta\alpha$	+ 0·4634 $\Delta\delta$	− 0·041 $\Delta\pi$	−	0·220 z	+	1·262	= 0
	LXIX.	·8892	·4483	·038		·225		0·076	= 0
	LXX.	·8972	·4319	·035		·230		1·057	= 0
Morning Observations.[1] Nov. 26.	LXXI.	− 0·9700 $\Delta\alpha$	+ 0·2206 $\Delta\delta$	+ 0·061 $\Delta\pi$	−	0·334 z'	+	0·694	= 0
	LXXII.	·9744	·2018	·070		·350		0·061	= 0
	LXXIII.	·9757	·1947	·073		·355		0·227	= 0

Juno compared with ν, November 29 and 30, 1874.

Morning Observations. Nov. 29.	LXXVII.	+ 0·8097 $\Delta\alpha$	− 0·5809 $\Delta\delta$	− 0·060 $\Delta\pi$	−	0·336 z'	+	0·974	= 0
	LXXVIII.	·8007	·5934	·065		·330		0·497	= 0
	LXXIX.	·7931	·6035	·068		·325		0·654	= 0
Evening Observations. Nov. 30.	LXXX.	− 0·0030 $\Delta\alpha$	− 1·0000 $\Delta\delta$	− 0·021 $\Delta\pi$	−	0·218 z	−	3·219	= 0
	LXXXI.	·0276	0·9996	·021		·218		3·105	= 0

[1] Cloud and bad definition. Weight ¼.

CHAPTER XI.

CORRECTION OF THE EQUATIONS FOR ERRORS IN THE TABLES OF JUNO.

The equations are still affected by the outstanding error of the tables. If this error is constant no harm is done, but if variable then the tabular motion does not represent the actual motion between the observations of the evening and morning.

To investigate this we have availed ourselves of the three following series of observations of Juno near the opposition of 1874 :—

1. Greenwich meridian observations (communicated by Sir G. B. Airy).

2. Washington meridian observations ('Ast. Nach.,' 2078).

3. A series of extra meridian differential observations made with the equatorial at Cambridge, U.S., by Mr. Willson, the stars of comparison being observed with the meridian circle of the same observatory by Mr. Rogers ('Ast. Nach.,' 2051).

The results of these observations are given below.

Greenwich Meridian Observations (communicated by Sir G. B. Airy).

	O—C	
1874	ΔR sec.	Dec. "
November 9	+ 8·33	+ 17·25
„ 10	+ 8·38	+ 18·94
„ 11	+ 8·41	+ 17·23
„ 13	+ 8·35	+ 14·15
„ 19	+ 8·10	+ 14·91

Washington Meridian Observations ('Ast. Nach.,' 2078).

1874	sec.	"
November 16	+ 8·18	+ 16·82
„ 21	...	+ 18·05
„ 25	+ 8·04	...
December 2	+ 7·75	...
„ 4	+ 7·50	+ 11·67
„ 5	+ 7·39	+ 16·76
„ 14	+ 7·00	+ 10·70
„ 18	+ 6·81	+ 9·49
„ 19	+ 6·51	+ 9·91
„ 21	+ 6·67	+ 10·75

CAMBRIDGE, U.S., OBSERVATIONS WITH EQUATORIAL AND COMPARISON STARS ('AST. NACH.,' 2051).

1874, Camb. M. T.	sec.	"
October 15 . . .	+ 7·89	...
„ 16 . . .	+ 7·84	+ 17·69
„ 20[1] . . .	...	+ 19·79
„ 21 . . .	+ 8·03	+ 19·82
„ 23 . . .	...	+ 17·64
„ 26 . . .	+ 8·40	+ 19·83
„ 26 . . .	+ 8·25	+ 20·97
„ 28 . . .	+ 8·45	+ 16·32
„ 30 . . .	+ 8·32	+ 18·53
„ 30 . . .	+ 8·43	+ 20·22

1874, Camb. M. T.	sec.	"
November 2 . . .	+ 8·55	+ 15·68
„ 3 . . .	+ 8·40	+ 19·49
„ 6 . . .	+ 8·46	+ 17·53
„ 7 . . .	+ 8·31	+ 19·05
„ 7 . . .	+ 8·70	+ 19·11
„ 9 . . .	+ 8·43	+ 16·34
„ 12 . . .	+ 8·54	+ 16·94
„ 24 . . .	+ 8·07	+ 14·36

[1] There appears to be some error of observation or reduction in the observations of October 18 and 19, the tabular error for ÆR coming out + 6ˢ·01 on the 18th, and 6ˢ·57 on the 19th. These observations have not been employed.

These results show very clearly that the tabular error varies nearly with the distance, and may therefore be expected to be well represented by the expression

$$\frac{1}{\Delta}(a + b\,t + c\,t^2),$$

where Δ = the distance from the earth, t = the time from opposition.

Forming from the preceding results equations of condition to find the factors a, b, and c, of which the factors are respectively $\frac{1}{\Delta}$, $\frac{t}{\Delta}$, and $\frac{t^2}{\Delta}$, we have the following equations, where G, W, and C; G_1, W_1, and C_1 represent the systematic errors of the Greenwich, Washington, and Cambridge observation in ÆR and declination.

EQUATIONS RESULTING FROM OBSERVATIONS OF JUNO AT GREENWICH, WASHINGTON, AND CAMBRIDGE, U.S.

$$\frac{1}{\Delta}a + \frac{t}{\Delta}b + \frac{t^2}{\Delta}c = (O-C)\text{—}(\textit{systematic correction}).$$

GREENWICH.

				$\Delta\alpha$	$\Delta\delta$
·969 a	+ 4·8 b	+ 24·2 c		= 8·33 − G	= 17·25 − G_1
·968	+ 5·8	+ 34·8		= 8·38 − G	= 18·94 − G_1
·967	+ 6·8	+ 47·4		= 8·41 − G	= 17·23 − G_1
·963	+ 8·7	+ 78·0		= 8·35 − G	= 14·15 − G_1
·949	+ 14·2	+ 213·5		= 8·10 − G	= 14·91 − G_1

WASHINGTON.

						$\Delta\alpha$	$\Delta\delta$
·957 a	+	11·7 b	+	142·4 c		= 8·18 − W	= 16·82 − W_1
·943	+	16·2	+	278·9		...	= 18·05 − W_1
·928	+	19·7	+	417·0		= 8·04 − W	...
·898	+	25·2	+	709·1		= 7·75 − W	...
·889	+	26·8	+	805·4		= 7·50 − W	= 11·67 − W_1
·884	+	27·5	+	855·0		= 7·39 − W	= 16·76 − W_1
·838	+	33·6	+	1347·5		= 7·00 − W	= 10·70 − W_1
·817	+	36·0	+	1588·9		= 6·81 − W	= 9·49 − W_1
·812	+	36·6	+	1651·6		= 6·51 − W	= 9·91 − W_1
·801	+	37·7	+	1776·9		= 6·67 − W	= 10·75 − W_1

CAMBRIDGE, U.S.

·932 a	−	18·5 b	+	365·3 c	= 7·89 − C	...
·935	−	17·6	+	330·1	= 7·84 − C	= 17·69 − C_1
·945	−	14·1	+	209·8	...	= 19·79 − C_1
·948	−	13·2	+	183·2	= 8·03 − C	= 19·82 − C_1
·957	−	11·3	+	133·2	...	= 17·64 − C_1
·963	−	8·6	+	76·3	= 8·40 − C	= 19·83 − C_1
·963	−	8·6	+	76·3	= 8·25 − C	= 20·97 − C_1
·967	−	6·6	+	44·7	= 8·45 − C	= 16·32 − C_1
·969	−	4·8	+	24·2	= 8·32 − C	= 18·53 − C_1
·969	−	4·8	+	24·2	= 8·43 − C	= 20·22 − C_1
·972	−	1·8	+	3·5	= 8·55 − C	= 15·68 − C_1
·972	−	0·9	+	0·8	= 8·40 − C	= 19·49 − C_1
·972	+	2·0	+	4·3	= 8·46 − C	= 17·53 − C_1
·971	+	2·9	+	8·7	= 8·31 − C	= 19·05 − C_1
·971	+	2·9	+	8·7	= 8·70 − C	= 19·11 − C_1
·969	+	4·9	+	25·2	= 8·43 − C	= 16·34 − C_1
·965	+	7·8	+	63·3	= 8·54 − C	= 16·94 − C_1
·932	+	18·6	+	372·8	= 8·07 − C	= 14·36 − C_1

The resulting normal equations, neglecting G, W, C; G_1, W_1, and C_1, are—

$\Delta\alpha$

							sec.
28·010 a	+	248·8 b	+	11303·3 c	=	240·49
212·526	+	9720·1	+	297889·6	=	1789·17
9728·59	+	297889·6	+	18377287·5	=	81478·54

$\Delta\delta$

							″
28·097 a_1	+	213·2 b_1	+	10433·8 c_1	=	495·94
179·994	+	8943·6	+	278618·3	=	2260·00
8952·15	+	278618·3	+	17706675·0	=	130372·04

The resulting values (converting ΔR into arc) are—

For Δ α			For Δ δ	
	sec.	″		″
a . .	= 8·6433	= 129·650	a_1 . . .	18·610
b . .	= − 0·000059	= − 0·00089	b_1 . . .	− 0·11396
c . .	= − 0·000141	= − 0·002115	c_1 . . .	− 0·000253

Substituting these values in the equations, we obtain for values of G, W, C; G_1, W_1, C_1, the following :—

sec.	″	sec.	″
G = − ·042	G_1 = − 0·23	C = − ·116	C_1 = ...
+ ·018	+ 1·59	− ·195	+ 1·63
+ ·059	+ 0·02	...	+ 0·67
+ ·037	− 2·76	− ·139	+ 0·72
− ·072	− 1·08	...	− 1·42
		+ ·087	+ 0·95
G = ± ·000	G_1 = − 0·49	− ·063	− 2·09
		+ ·098	− 2·42
sec.	″	− ·052	− 0·04
W = − ·071	W_1 = + 0·38	+ ·058	+ 1·65
...	+ 2·42	+ ·149	− 2·61
+ ·078	...	− ·001	+ 1·30
+ ·090	...	+ ·059	− 0·33
− ·068	− 1·62	− ·082	+ 1·31
− ·128	+ 3·66	+ ·308	+ 1·37
− ·051	− 0·73	+ ·059	− 1·13
− ·026	− 1·21	+ ·208	− 0·11
− ·273	− 0·61	+ ·067	− 0·77
± ·000	+ 0·59		
W = − ·050	W_1 = + 0·36	C = + ·028	C_1 = − 0·02

The residuals in the Cambridge and Washington term or values of C and W, when arranged together in order of time, exhibit a marked tendency to become negative towards the extreme dates, so much so that we have been led to investigate independently the systematic errors of the three series of observations, and, to reduce all to an uniform system, we have attempted to find the corrections for each system to the standard of Newcomb's right ascensions and Auwers's declinations.

To correct the Cambridge star-places, application was made to Mr. A. Searle, assistant in charge of Harvard College Observatory, who kindly communicates the following particulars :—

'The observations made with the meridian circle are differential.

'The observations of comparison stars for places of Juno, made with the meridian circle at Harvard College Observatory, are—

Date	Comparison stars observed	Determining stars observed for	
		Clock error	Equatorial point
1874, December 12	*c, d, g, k, m, n, p, t, w*	ε Piscium 38 Cassiop. η Piscium α Ceti	ε Piscium τ Piscium α Urs. Min. 38 Cassiop. η Piscium α Ceti
1874, December 21	*a, b, c, d, e, g, j, k, m, o, q, u, x, z*	β Arietis α Arietis α Ceti 50 Cassiop. γ Ceti	τ Piscium 50 Cassiop. α Urs. Min. α Arietis β Arietis γ Ceti α Ceti
1874, December 23	*a, b, c*	ο Piscium ι Cassiop. α Arietis γ Ceti	ο Piscium ι Cassiop. α Arietis γ Ceti
1875, January 5	*a, b, k, m, o, q, r, u, z*	α Ceti η Tauri δ Persei	α Ceti η Tauri δ Persei
1875, January 10	*f, n, p, s, v, y*	ι Cassiop. γ Tauri γ Ceti	ι Cassiop. γ Tauri γ Ceti
1875, January 11	*f, n, p, s, v, y*	γ Tauri ι Aurigæ α Tauri	γ Tauri ι Aurigæ α Tauri ε Urs. Min. 9 Camel.
1875, January 14	*e, h, o, t, w*	γ Ceti α Aurigæ ι Aurigæ β Orionis	γ Ceti β Orionis ι Aurigæ
1875, January 16	*e, i, o, t, w*	α Tauri α Aurigæ ι Aurigæ β Orionis	α Tauri β Orionis ι Aurigæ
1875, January 27	*h, i, j, x*	α Arietis α Ceti ι Cassiop. α Aurigæ γ Ceti β Orionis β Tauri	α Arietis α Aurigæ ι Cassiop. β Orionis γ Ceti β Tauri α Ceti
1875, January 30	*h, i, k, r, x*	α Aurigæ β Tauri β Orionis	α Aurigæ β Tauri β Orionis

'The places of the determining stars are taken from the American Ephemeris, except as follows:—τ Piscium is from the Berlin 'Mittlere Oerter von 539 Sternen u. s. w.,' and the following corrections in $\mathcal{A}R$ are applied to some of the stars:—ε Piscium, $-0^s.01$; η Piscium, $+0^s.05$; ο Piscium, $-0^s.07$; α Arietis, $+0^s.01$; γ Ceti, $-0^s.02$; α Ceti, $-0^s.01$; δ Persei, $+0^s.06$; η Tauri, $+0^s.06$. These corrections to the American Ephemeris are taken from a discussion by Mr. A. W. Rogers. In the reduction, only four values for the correction for the equatorial point were used: one for the period December 12—January 11, one for January 14, one for January 16, and one for January 27—January 30.'

The places of the determining stars will thus be as given on next page. The corrections given to reduce to Newcomb's $\mathcal{A}R$s and Auwers's Declinations are derived in part from the catalogue in Vol. II., in part by reduction of the best modern observations on the same system.

Star	Right ascension, employed 1875·0	Correction to Newcomb's AR	Declination, employed 1875·0	Correction to Auwers's Dec.
	h. m. sec.	sec.	° ′ ″	″
ε Piscium . .	0 56 27·41	+0·03	+ 7 13 0·47	+0·13
τ Piscium . .	...	+0·03	+29 25 31·51	+0·20
38 Cassiop. . .	1 21 57·41	0·00	+69 37 12·89	+0·26
η Piscium . .	1 24 47·72	+0·05	+14 42 3·80	−0·66
ο Piscium . .	1 38 47·70	+0·05	+ 8 31 40·38	−0·63
β Arietis . .	1 47 44·24	0·00	+20 11 47·02	−0·97
50 Cassiop. . .	1 52 47·37	−0·02	+71 48 52·78	+1·23
α Arietis . .	2 0 7·80	0·00	+22 52 13·99	−0·68
ι Cassiop. . .	2 18 47·35	+0·04	+66 50 18·19	+0·28
γ Ceti . . .	2 36 49·48	+0·02	+ 2 42 28·72	−1·43
α Ceti . . .	2 55 44·77	−0·02	+ 3 35 52·93	−0·29
δ Persei . . .	3 34 1·83	+0·03	+47 23 8·01	+0·93
η Tauri . . .	3 40 3·42	+0·05	+23 43 0·94	−0·35
γ Tauri . . .	4 12 40·87	+0·01	+15 19 27·11	−0·80
α Tauri . . .	4 28 44·96	+0·01	+16 15 22·95	−0·87
9 Camel. . .	...	...	+66 7 37·30	−0·33
ι Aurigæ . .	4 48 51·30	−0·02	+32 57 58·09	−0·72
α Aurigæ . .	5 7 27·44	−0·01	+45 52 5·76	−0·43
β Orionis . .	5 8 31·86	+0·01	− 8 20 51·52	−1·39
β Tauri . . .	5 18 23·45	+0·01	+28 29 58·76	−0·54
ε Urs. Min. . .	...	...	+82 14 22·77	−0·21

The corrections to the right ascensions and declinations, determined differentially from these places, by the application of the accompanying corrections, will be for each day the mean of the corrections corresponding to the standard stars observed.

The following table gives the resulting corrections, those for declination being finally combined in the four periods adopted for zenith points :—

1874–5	Corrections to AR	Corrections to Dec.	
	sec.	″	″
December 12	+0·012	−0·07	
,, 21	−0·004	−0·28	
,, 23	+0·028	−0·62	−0·35
January 5	+0·020	+0·10	
,, 10	+0·023	−0·65	
,, 11	0·000	−0·59	
,, 14	0·000	−1·18	−1·18
,, 16	−0·003	−0·99	−0·99
,, 27	+0·007	−0·59	−0·63
,, 30	+0·003	−0·67	

Applying these corrections, corresponding to the date of observation, to the individual observations of each star of comparison, and taking the mean, we obtain the systematic

correction to be applied to each star to reduce it to the standards of Newcomb and Auwers in Æ and Declination respectively.

Comp. star	$\Delta\alpha$	$\Delta\delta$	Comp. star	$\Delta\alpha$	$\Delta\delta$	Comp. star	$\Delta\alpha$	$\Delta\delta$	Comp. star	$\Delta\alpha$	$\Delta\delta$
	sec.	"		sec.	"		sec.	"		sec.	"
a	+0·015	−0·35	*h*	+0·003	−0·54	*o*	+0·004	−0·72	*v*	+0·012	−0·35
b	+0·015	−0·35	*i*	+0·003	−0·75	*p*	+0·012	−0·35	*w*	−0·001	−1·09
c	+0·012	−0·35	*j*	+0·001	−0·44	*q*	+0·008	−0·35	*x*	+0·012	−0·54
d	+0·004	−0·35	*k*	+0·008	−0·44	*r*	+0·012	−0·49	*y*	+0·012	−0·35
e	−0·002	−0·84	*l*	...	...	*s*	+0·012	−0·35	*z*	+0·008	−0·35
f	+0·012	−0·35	*m*	+0·009	−0·35	*t*	+0·003	−0·84			
g	+0·004	−0·35	*n*	+0·012	−0·35	*u*	+0·009	−0·35			

Dividing the time of observation into four nearly equal epochs, we have—

	Mean of corrections of comparison stars	
	$\Delta\alpha$ sec.	$\Delta\delta$ "
October 15–23	+0·009	−0·51
October 26–November 3 . . .	+0·008	−0·45
November 6–18	+0·005	−0·48
November 19–24	+0·008	−0·47

These corrections exhibit no systematic error, depending on the time, and the mean may with safety be applied throughout, viz. $\Delta\alpha + 0^s{\cdot}008$; $\Delta\delta - 0''{\cdot}48$. In Vol. III. it will be found that for 3^h Æ the correction of the Greenwich Catalogue for 1864 (upon whose places the Greenwich Æ chiefly depends) to reduce to Newcomb's Catalogue is $+ 0^s{\cdot}02$, and for the Washington Catalogue $+ 0^s{\cdot}01$.

In Newcomb's paper on the 'Distance of the Sun' ('Washington Observations for 1865,' Appendix II.), the author gives the systematic correction for Washington declinations near the equator, to reduce to Auwers's standard $= - 1''{\cdot}50$, and Greenwich declination $+ 0''{\cdot}20$. Adopting these we have—

	$\Delta\alpha$ sec.	$\Delta\delta$ "
For Greenwich	+0·02	+0·20
For Washington	+0·01	−1·50
For Cambridge (U.S.)	+0·01	−0·48

The Cambridge determining stars not being always near the same declination with the comparison stars, there is still a small uncertainty due to unknown periodic error of graduation and flexure, &c., in the circle, which may affect the systematic correction thus arrived at, but at present the data for its elimination are not available.

Adopting, then, the above corrections as definitive, and substituting $\frac{\cos\delta}{\Delta}$ for $\frac{1}{\Delta}$ in the coefficients of a, $b\,t$, and $b\,t^2$ in the right ascension observations, we obtain the following equations from the observations of each day. For those days on which two stars are observed in the Cambridge series, the equations are combined and multiplied by $\sqrt{2}$. These equations are marked *:—

Equations resulting from the Observations of Juno in $\mathcal{R}$.

Coefficient of $a = \frac{\cos\delta}{\Delta}$; coefficient of $b = \frac{t\cos\delta}{\Delta}$; coefficient of $c = \frac{t^2\cos\delta}{\Delta}$

From Greenwich Observations.

0·966	a	+ 4·8	b	+ 24·1	c	= 8·35	sec.	
0·965		+ 5·8		+ 34·7		= 8·40		
0·964		+ 6·8		+ 47·3		= 8·43		

0·959	a	+ 8·7	b	+ 77·7	c	= 8·37	sec.	
0·944		+ 14·1		+ 212·4		= 8·12		

From Washington Observations.

0·953	a	+ 11·7	b	+ 141·8	c	= 8·19	sec.	
0·923		+ 19·6		+ 415·0		= 8·05		
0·894		+ 25·1		+ 705·6		= 7·76		
0·885		+ 26·6		+ 801·4		= 7·51		
0·880		+ 27·4		+ 850·7		= 7·40		

0·835	a	+ 33·5	b	+ 1342·1	c	= 7·01	sec.	
0·814		+ 35·9		+ 1582·5		= 6·82		
0·809		+ 36·5		+ 1645·0		= 6·52		
0·799		+ 37·6		+ 1771·6		= 6·68		

From Cambridge, U.S., Observations.

*1·318	a	− 26·2	b	+ 516·6	c	= 11·17	sec.	
*1·322		− 24·9		+ 466·8		= 11·10		
*1·341		− 18·7		+ 259·1		= 11·37		
*1·361		− 12·2		+ 107·8		= 11·79		
0·966		− 6·6		+ 44·7		= 8·46		
*1·369		− 6·8		+ 34·2		= 11·86		
*1·372		− 2·5		+ 4·9		= 12·11		

0·970	a	− 0·9	b	+ 0·8	c	= 8·41	sec.	
0·970		+ 2·0		+ 4·3		= 8·47		
*1·369		+ 4·1		+ 12·3		= 12·05		
0·966		+ 4·9		+ 25·1		= 8·44		
0·961		+ 7·8		+ 63·0		= 8·55		
*1·311		+ 26·2		+ 524·6		= 11·43		

Resulting Normal Equations by Method of Least Squares.

30·528	a +	179·3	b +	10822·5	c =	263·10
179·3	+	10837·8	+	287425·1	=	1527·20
10822·5	+	287425·1	+	13108137·4	=	91268·18

		sec.	
a	=	8·723	= 130″·845
b	=	0·0070	= 0·1050
c	= −	0·000392	= − 0·00588

The Equations resulting from the Observations of Juno in Declination.

Coefficient of $a_1 = \frac{1}{\Delta}$; coefficient of $b_1 = \frac{t}{\Delta}$; coefficient of $c_1 = \frac{t^2}{\Delta}$

From Greenwich Observations.

0·969	a_1	+ 4·8	b_1	+ 24·2	c_1	= 17·45		
0·968		+ 5·8		+ 34·8		= 19·14		
0·967		+ 6·8		+ 47·4		= 17·43		

0·963	a_1	+ 8·7	b_1	+ 78·0	c_1	= 14·35		
0·949		+ 14·2		+ 213·5		= 15·11		

From Washington Observations.

0·957	a_1	+ 11·7	b_1	+ 142·4	c_1	= 15·32		
0·943		+ 16·2		+ 278·9		= 16·55		
0·889		+ 26·8		+ 805·4		= 10·17		
0·884		+ 27·5		+ 855·0		= 15·26		

0·838	a_1	+ 33·6	b_1	+ 1347·5	c_1	= 9·20		
0·817		+ 36·0		+ 1588·9		= 7·99		
0·812		+ 36·6		+ 1651·6		= 8·41		
0·801		+ 37·7		+ 1776·9		= 9·25		

FROM CAMBRIDGE, U.S., OBSERVATIONS.

*1·322	a_1	− 24·9	b_1	+ 466·8	c_1	= 24·34
0·945		− 14·1		+ 209·8		= 19·31
*1·341		− 18·7		+ 259·1		= 27·35
*1·353		− 16·0		+ 188·4		= 24·27
*1·362		− 12·2		+ 107·9		= 28·17
0·967		− 6·6		+ 44·7		= 15·84
*1·370		− 6·8		+ 34·2		= 26·73

*1·375	a_1	− 2·5	b_1	+ 4·9	c_1	= 21·50
0·972		− 0·9		+ 0·8		= 19·01
0·972		+ 2·0		+ 4·3		= 17·05
*1·373		+ 4·1		+ 12·3		= 26·30
0·969		+ 4·9		+ 25·2		= 15·86
0·965		+ 7·8		+ 63·3		= 16·46
*1·318		+ 26·3		+ 527·2		= 19·63

RESULTING NORMAL EQUATIONS BY METHOD OF LEAST SQUARES.

30·895	a_1	+ 155·8	b_1	+ 9907·3	c_1	= 529″·83
155·8		+ 9907·3		+ 275789·7		= 1430·92
9907·3		+ 275789·7		+ 12421114·4		= 133755·69

and

$$a_1 = 18''\cdot123$$
$$b_1 = -\ 0\cdot0996$$
$$c_1 = -\ 0\cdot00147$$

Substituting in the original equations these values of a, b, c; a_1, b_1, c_1, the residuals in $\mathcal{R}$ are—

Greenwich observations

sec.
+ 0·101
+ 0·045
+ 0·009
+ 0·026
+ 0·131

Washington observations

sec.
+ 0·150
− 0·024
− 0·062
+ 0·083
+ 0·135
− 0·016
− 0·087
+ 0·150
− 0·110

Cambridge (U.S.) observations

sec.
− 0·058
+ 0·075
+ 0·096
− 0·045
− 0·097
+ 0·021
− 0·162
+ 0·045
+ 0·003
− 0·084
− 0·010
− 0·137
− 0·016

And the residuals in declination—

Greenwich observations

″
− 0·41
− 2·23
− 0·66
+ 2·12
+ 0·37

Washington observations

″
+ 0·64
− 1·48
+ 2·09
− 3·24
+ 0·66
+ 0·89
+ 0·23
− 1·10

Cambridge (U.S.) observations

″
+ 1·41
− 1·10
− 1·57
+ 1·56
− 2·43
+ 2·27
− 1·27
+ 3·66
− 1·30
+ 0·36
− 1·85
+ 1·17
+ 0·16
+ 0·86

The Washington and Cambridge series are now well represented in ÆR, but the residuals of the Greenwich series are all positive, as if some systematic correction was still required.

According to the first system, the probable error of an observation of ÆR is $\pm$ 0^s·078; according to the present system, $\pm$ 0^s·060. The probabilities are therefore in favour of the second system. It has been considered best to reduce the observations on both systems, and accordingly we adopt the tabular corrections to the 'Nautical Almanac' tables of Juno as follows :—

1st System.

Tabular correction of $\text{Æ}\text{R} = \frac{1}{\Delta}(129''{\cdot}650 - 0{\cdot}00089\,t - 0{\cdot}002115\,t^2)$.

" " of declination $= \frac{1}{\Delta}\ (18''{\cdot}610 - 0{\cdot}11396\,t - 0{\cdot}000253\,t^2)$.

2nd System.

Tabular correction of $\text{Æ}\text{R} = \frac{\cos\delta}{\Delta}\ (130''{\cdot}845 + 0{\cdot}0070\,t - 0{\cdot}000392\,t^2)$.

" " of declination $= \frac{1}{\Delta}\ (18''{\cdot}123 - 0{\cdot}0996\,t - 0{\cdot}00147\,t^2)$.

But in the construction of Table VI., upon which the equations of condition are founded, a uniform correction of + 120″ in ÆR, and + 15″ in declination, has been already applied; the outstanding tabular correction required is therefore (correction in $\text{Æ}\text{R} - 120''$) (correction in declination $- 15''$)—that is to say, putting

$\delta\alpha =$ (correction in ÆR by either of the above formulæ) $- 120''{\cdot}0$.
$\delta\delta =$ (" dec. " " ") $- 15''{\cdot}0$

To each equation of distance must be added

$$f'.\delta\alpha + f''.\delta\delta,$$

and to each equation of position angle

$$f_{,}.\delta\alpha + f_{,,}.\delta\delta.$$

The following table gives the value of Δ and t for each group of observations, and the values of $\delta\alpha$ and $\delta\delta$ according to both systems :—

No. of group	Log. of dist. from earth log. Δ	Time from opposition t	Tabular errors. 1st system		Tabular errors. 2nd system	
			$\Delta\alpha$	$\Delta\delta$	$\Delta\alpha$	$\Delta\delta$
		d	″	″	″	″
I.	0·013850	5·6755	...	...	...	...
II.	0·013866	5·7050	...	...	...	...
III.	0·013875	5·7213	...	...	...	...
IV.	0·013887	5·7423	...	...	...	...
V.	0·014024	5·9909	...	...	...	...
VI.	0·014034	6·0089	...	...	...	...
VII.	...	...	...	...	...	...
VIII.	...	...	...	...	...	...
IX.	0·014410	6·6364	...	...	...	...
X.	0·015081	7·6350	+ 5·099	+ 1·630	+ 6·375	+ 1·689
XI.	0·015095	7·6550	5·094	1·626	6·370	1·685
XII.	0·015110	7·6773	5·089	1·624	6·365	1·683
XIII.	0·015123	7·6938	5·085	1·621	6·361	1·680
XIV.	0·015287	7·9179	5·031	1·589	6·315	1·645
XV.	0·015307	7·9439	5·024	1·585	6·308	1·641
XVI.	0·015323	7·9662	5·018	1·583	6·302	1·639
XVII.	0·015338	7·9857	5·014	1·579	6·298	1·635
XVIII.	0·015833	8·6221	4·850	1·488	6·145	1·541
XIX.	0·015848	8·6397	4·845	1·485	6·140	1·538
XX.	0·015861	8·6564	4·841	1·483	6·136	1·536
XXI.	0·015880	8·6795	4·835	1·479	6·130	1·532
XXII.	0·016100	8·9469	4·761	1·440	6·066	1·493
XXIII.	0·016124	8·9746	4·753	1·436	6·058	1·489
XXIV.	0·016154	9·0108	4·742	1·430	6·047	1·483
XXV.	0·016155	9·0117	+ 4·742	+ 1·430	+ 6·047	+ 1·483
XXVI.	0·017019	9·9869	...	...	...	..
XXVII.	...	...	...	...	...	...
XXVIII.	0·017686	10·6814	+ 4·235	+ 1·180	+ 5·548	+ 1·217
XXIX.	0·017706	10·7026	4·229	1·177	5·542	1·214
XXX.	0·017724	10·7212	4·223	1·174	5·536	1·211
XXXI.	0·017740	10·7369	4·218	1·171	5·531	1·208
XXXII.	0·017920	10·9165	4·158	1·144	5·471	1·178
XXXIII.	0·017939	10·9357	4·152	1·141	5·465	1·175
XXXIV.	0·017961	10·9572	4·145	1·138	5·458	1·172
XXXV.	0·017984	10·9791	+ 4·137	+ 1·135	+ 5·450	+ 1·169
XXXVI.	0·018000	10·9953	...	...	...	...
XXXVII.	0·018023	11·0181	...	...	...	...
XXXVIII.	0·019805	12·6527	...	...	...	...
XXXIX.	0·020990	13·6404	...	...	...	...
XL.	0·021332	13·9141	+ 3·034	+ 0·670	+ 4·312	+ 0·661
XLI.	0·021363	13·9384	3·024	0·667	4·302	0·658
XLII.	0·021390	13·9602	3·015	0·664	4·293	0·655
XLIII.	0·021418	13·9818	3·005	0·660	4·283	0·651
XLIV.	0·022298	14·6613	2·717	0·549	3·994	0·529
XLV.	0·022324	14·6811	2·708	0·546	3·985	0·526
XLVI.	0·022350	14·6999	2·700	0·543	3·977	0·523
XLVII.	0·022370	14·7160	+ 2·692	+ 0·540	+ 3·968	+ 0·520

No. of group	Log. of dist. from earth log. Δ	Time from opposition t	Tabular errors. 1st system		Tabular errors. 2nd system	
			$\Delta\alpha$	$\Delta\delta$	$\Delta\alpha$	$\Delta\delta$
		d				
XLVIII.	0·023631	15·6392	+2″·281	+0″·387	+3″·523	+0″·345
XLIX.	0·023662	15·6620	2·271	0·383	3·513	0·341
L.	0·024043	15·9319	2·148	0·338	3·390	0·296
LI.	0·024078	15·9564	2·136	+0·334	3·378	+0·292
LII.	0·028182	18·6411	0·799	−0·124	1·931	−0·235
LIII.	0·028208	18·6575	0·791	0·125	1·923	0·236
LIV.	0·028243	18·6785	0·779	0·131	1·911	0·242
LV.	0·028277	18·6995	0·769	0·134	1·901	0·245
LVI.	0·030293	19·9032	0·116	0·343	1·191	0·488
LVII.	0·030350	19·9362	0·099	0·350	1·174	0·495
LVIII.	0·030385	19·9563	0·087	0·354	1·162	0·499
LXIX.	0·030404	19·9674	+0·080	0·355	1·155	0·500
LX.	0·031582	20·6409	−0·298	0·474	0·728	0·644
LXI.	0·031613	20·6588	0·308	0·477	0·718	0·647
LXII.	0·031642	20·6750	0·318	0·480	0·708	0·650
LXIII.	0·031670	20·6905	0·326	0·483	0·700	0·653
LXIV.	0·032049	20·9038	0·449	0·521	0·563	0·700
LXV.	0·032076	20·9189	0·456	0·523	0·556	0·702
LXVI.	0·032108	20·9366	0·467	0·526	0·545	0·705
LXVII.	0·032143	20·9566	0·479	0·530	0·533	0·709
LXVIII.	0·033381	21·6376	0·876	0·651	0·091	0·850
LXIX.	0·033403	21·6495	0·884	0·654	0·083	0·853
LXX.	0·033428	21·6627	0·891	0·656	+0·076	0·855
LXXI.	0·033875	21·9048	1·036	0·698	−0·078	0·906
LXXII.	0·033937	21·9382	1·055	0·704	0·097	0·912
LXXIII.	0·033962	21·9516	−1·062	−0·707	−0·104	−0·915
LXXIV.	...	...	...	...	...	...
LXXV.	0·035268	22·6451	...	...	...	...
LXXVI.	0·037765	23·9273	...	...	...	...
LXXVII.	0·039727	24·9002	−2·900	−1·241	−2·160	−1·559
LXXVIII.	0·039766	24·9189	2·914	1·243	2·174	1·561
LXXIX.	0·039800	24·9357	2·923	1·248	2·183	1·566
LXXX.	0·041315	25·6668	3·403	1·381	2·725	1·728
LXXXI.	0·041343	25·6801	−3·411	−1·384	−2·733	−1·731

CHAPTER XII.

SOLUTION OF THE EQUATIONS AND DEDUCTION OF THE PARALLAX.

BEFORE applying the tabular errors it is convenient to take the mean of the equations for each evening and morning. Indeed, when two stars of comparison are observed symmetrically, this is the only rigid method. The object of symmetrical observation—that is, *a*, *b*, *b*, *a*—is to eliminate progressive change; and on the supposition of progressive change the values of z are only exact in the *mean* of the two equations from *a* and the two equations from *b*. We shall then have two equations from the evening, and two from the morning, observations of distance—four equations in all. The fifth equation is derived from the position angles. First, by subtraction, E and W are eliminated from the mean position-angle equations, and there result two equations—one from the evening and one from the morning observations—containing only $\Delta\alpha$, $\Delta\delta$, and $\Delta\pi$, in which the factors of $\Delta\pi$ will be very small. The sum of these two equations gives our fifth equation; and since a small error in the position angle has no sensible influence on the distance, and since both the value and multiple of $\Delta\pi$ are very small, we may, in deducing the parallax from the distances, omit $\Delta\pi$ from this equation with perfect safety.

To apply the tabular corrections to the equations so obtained it is necessary to add the sum of

$$f'\,\Delta\alpha + f''\,\Delta\delta \text{ to each distance equation}$$

and

$$f_{,}\,\Delta\alpha + f_{,,}\,\Delta\delta \text{ to each position-angle equation,}$$

where $\Delta\alpha$ and $\Delta\delta$ are taken from the tables, pp. 205 and 206.

In the equations so obtained and corrected for tabular error, the places of the stars of comparison are supposed to be absolutely determined by the meridian observations, and such a supposition is of course erroneous.

The resulting values of $\Delta\alpha$ and $\Delta\delta$ will be directly affected by errors in the places of the comparison stars, but so far as our problem is concerned this is of no consequence, as they disappear when the same stars are employed in the evening and morning observations.

But the values of z, z' and $\Delta\pi$ are also affected by these errors. The error of the scale value being determined by the stars of comparison, the values of z and z' depend on the accuracy of the tabular distance between these stars.

An error of Δs in this distance will produce an error equal to $\sigma \times \frac{\Delta s}{s}$, where σ is the tabular distance travelled by the planet between the evening and morning.

In the three groups of observations where two stars have been observed, the mean value of s is in round numbers 8800″, and the mean value of σ is 390″.

The probable error of a single meridian observation by Dr. Copeland is as follows :—

In right ascension $= \pm 0''.73$;
In declination . $= \pm 0''.44$;

so that the probable error of the absolute place of the star in any direction by chance is $\sqrt{\frac{(0''.73)^2 + (0''.44)^2}{2}} = \pm 0''.61$. There are in general five observations of each star, so that the probable error of the place of a star $\pm \frac{0''.61}{\sqrt{5}} = \pm 0''.27$; and the probable error of each tabular distance $= \pm 0''.27 \times \sqrt{2} = \pm 0''.38$.

The average probable error in the planet's motion due to scale value is therefore for each average night $390'' \times \frac{0''.38}{8800} = \pm 0''.017$.

Seeing that this error is accidental and small, we may allow it to enter as one of the accidental errors which disappear (or are diminished so as to become insensible) in the mean of a long series. As we desire this investigation to represent others in future, when we hope to have star-places still more rigidly determined, we shall complete the investigation, treating the star-places as absolutely known, their errors producing small differences of scale value which are eliminated in the mean.

The equations so found and corrected for tabular error on both systems for the days on which two comparison stars have been observed have simply to be solved as they stand to give the most probable values of $\Delta\pi$. The resulting values of $\Delta\alpha$, $\Delta\delta$, $\Delta\pi$, z, and z' are given with each group of equations, together with the values of E and W obtained by substituting the values of $\Delta\alpha$, $\Delta\delta$, and $\Delta\pi$ so found in the original equations resulting from the position angles, after these have been corrected for tabular error.

NOVEMBER 15, EVENING AND MORNING.

Juno compared with ζ and λ.

		First system	Second system
XXVIII. XXXI.	$-0.8087\,\Delta\alpha + 0.5835\,\Delta\delta - 4.745\,z - 0.023\,\Delta\pi$ . .	$= -0.906$	$= -0.133$
XXIX. XXX.	$+0.9385\,\Delta\alpha - 0.3358\,\Delta\delta - 4.186\,z + 0.035\,\Delta\pi$ . .	$= -0.691$	$= -0.531$
XXXII. XXXV.	$-0.8281\,\Delta\alpha + 0.5549\,\Delta\delta - 4.822\,z' + 0.064\,\Delta\pi$ . .	$= -1.170$	$= -0.100$
XXXIII. XXXIV.	$+0.9272\,\Delta\alpha - 0.3661\,\Delta\delta - 4.075\,z' - 0.066\,\Delta\pi$ . .	$= -1.201$	$= -0.004$
Position angles	$+1.403\,\Delta\alpha + 2.753\,\Delta\delta$	$= -1.042$	$= -2.984$

NOVEMBER 18, MORNING; 19, EVENING.

Juno compared with θ and μ.

		First system	Second system
XL. XLIII.	$-0.8122\,\Delta\alpha - 0.5789\,\Delta\delta - 3.619\,z' + 0.037\,\Delta\pi$ . .	$= -1.619$	$= -2.652$
XLI. XLII.	$+0.9105\,\Delta\alpha + 0.4038\,\Delta\delta - 4.101\,z' - 0.049\,\Delta\pi$ . .	$= -0.860$	$= -0.300$
XLIV. XLVII.	$-0.8212\,\Delta\alpha - 0.5658\,\Delta\delta - 4.077\,z - 0.052\,\Delta\pi$ . .	$= -2.717$	$= -3.754$
XLV. XLVII.	$+0.9134\,\Delta\alpha + 0.3698\,\Delta\delta - 3.641\,z + 0.053\,\Delta\pi$ . .	$= -1.532$	$= -0.375$
Position angles	$-1.744\,\Delta\alpha + 3.120\,\Delta\delta$	$= -4.366$	$= -2.093$

NOVEMBER 23, EVENING; 24, MORNING.

Juno compared with ι and χ.

		First system	Second system
LII. LV.	$-0.9949\,\Delta a + 0.0161\,\Delta\delta - 5.430\,z - 0.049\,\Delta\pi$	$= -2.192$	$= -1.063$
LIII. LIV.	$+0.9941\,\Delta a + 0.0439\,\Delta\delta - 4.336\,z + 0.052\,\Delta\pi$	$= -0.564$	$= -1.682$
LVI. LIX.	$-0.9948\,\Delta a - 0.0202\,\Delta\delta - 6.063\,z' + 0.063\,\Delta\pi$	$= -0.640$	$= 0.421$
LVII. LVIII.	$+0.9950\,\Delta a - 0.0058\,\Delta\delta - 3.692\,z' - 0.068\,\Delta\pi$	$= -0.592$	$= -0.478$
Position angles	$-0.030\,\Delta a + 2.939\,\Delta\delta$	$= -4.947$	$= -4.542$

The resulting values are—

	November 15 (*Evening and Morning*).		*November* 18 (*Morning*), 19 (*Evening*).		*November* 23 (*Evening*), 24 (*Morning*).	
	First system	Second system	First system	Second system	First system	Second system
Δa	$+0''.671$	$-0''.642$	$+0''.183$	$-1''.093$	$+0''.661$	$-0''.446$
$\Delta\delta$	-0.720	-0.758	-1.297	$+1.282$	-1.713	-1.550
$\Delta\pi$	-4.15	-4.09	-0.581	-0.548	$+0.570$	$+0.124$
z	$+0.0083$	$+0.0087$	-0.516	-0.516	$+0.272$	$+0.273$
z'	-0.0103	-0.0106	-0.289	-0.289	$+0.009$	$+0.010$
E	$+0'.35$		$-0'.07$		$-0'.16$	
W	$-1'.16$		$-1'.64$		$-1'.94$	

The mean of these values of z, z', E, and W we may now employ in the equations which result from the observations in which only one star of comparison has been employed.

These mean values are—

$$z = -0''.098$$
$$z' = -0''.096$$
$$\text{E} = +0'.04$$
$$\text{W} = -1'.58$$

Substituting the numerical equivalents of these quantities in the equations resulting from the comparisons with the stars θ, μ, and ν, and correcting for the tabular errors, we obtain the following equations :—

NOVEMBER 12, EVENING; 13, MORNING.

Juno compared with θ.

		First system	Second system
Distances	$0.9681\,\Delta a + 0.2371\,\Delta\delta + 0.0717\,\Delta\pi$	$= -0.938$	$= -2.186$
	$0.9891\,\Delta a + 0.1212\,\Delta\delta - 0.0570\,\Delta\pi$	$= -0.642$	$= -1.917$
	$0.7457\,\Delta a - 0.6608\,\Delta\delta + 0.0344\,\Delta\pi$	$= -0.323$	$= -0.606$
	$0.0552\,\Delta a - 0.9971\,\Delta\delta - 0.0293\,\Delta\pi$	$= -1.241$	$= -1.222$
Position angles	$0.9175\,\Delta a - 3.7555\,\Delta\delta - 0.033\,\Delta\pi$	$= -4.292$	$= -3.338$
	$0.6199\,\Delta a - 5.1275\,\Delta\delta - 0.165\,\Delta\pi$	$= -5.666$	$= -5.158$
	$-7.0541\,\Delta a - 7.9782\,\Delta\delta - 0.681\,\Delta\pi$	$= -18.013$	$= -27.579$
	$-9.7084\,\Delta a - 0.5578\,\Delta\delta + 0.667\,\Delta\pi$	$= -5.653$	$= -18.334$

NOVEMBER 25 AND 26.

Juno compared with μ.

		First system	Second system
Distances	0·7411 Δα + 0·6670 Δδ + 0·0508 Δπ . .	= − 0·350	= − 0·996
	0·5298 Δα + 0·8461 Δδ − 0·0129 Δπ . .	= − 0·650	= − 1·031
	− 0·8893 Δα + 0·4479 Δδ − 0·0374 Δπ . .	= − 1·536	= − 0·587
	− 0·8110 Δα + 0·1721 Δδ + 0·0563 Δπ . .	= − 1·076	= − 0·266
Position angles	6·932 Δα − 7·770 Δδ + 0·165 Δπ . .	= − 17·035	= − 8·609
	12·949 Δα − 8·296 Δδ − 0·968 Δπ . .	= − 21·141	= − 6·607
	6·873 Δα + 13·695 Δδ + 0·679 Δπ . .	= − 10·040	= − 13·958
	1·984 Δα + 9·703 Δδ + 0·098 Δπ . .	= − 11·964	= − 11·829

NOVEMBER 29 AND 30.

Juno compared with ν.

		First system	Second system
Distances	0·8006 Δα − 0·5926 Δδ − 0·0640 Δπ . .	= − 0·852	= − 0·077
	− 0·0153 Δα − 0·9998 Δδ − 0·0212 Δπ . .	= − 1·711	= − 1·374
Position angles	− 6·1146 Δα − 8·3915 Δδ + 0·189 Δπ . .	= − 17·871	= − 19·741
	− 15·9326 Δα + 0·2626 Δδ − 0·617 Δπ . .	= − 3·519	= − 14·413

To reduce the position-angle equations to an uniform weight by multiplying each by $\sqrt{w}$. Omitting the terms depending on $\Delta\pi$ in the position-angle equations, we find, combining them with the distance equations by the method of least squares, the equations given below :—

NOVEMBER 12 AND 13.

Juno compared with θ.

	First system	Second system
12·271 Δα + 2·209 Δδ + 0·037 Δπ . . .	= − 11·166	= − 27·182
2·209 Δα + 13·862 Δδ + 0·017 Δπ . . .	= − 20·113	= − 23·755
0·037 Δα + 0·017 Δδ + 0·0105 Δπ . . .	= − 0·0560	= − 0·1040

NOVEMBER 25 AND 26.

Juno compared with μ.

	First system	Second system
8·576 Δα − 1·740 Δδ + 0·018 Δπ . . .	= − 10·160	= − 1·335
− 1·740 Δα + 15·188 Δδ + 0·016 Δπ . . .	= − 22·104	= − 17·273
0·018 Δα + 0·016 Δδ + 0·0073 Δπ . . .	= − 0·0125	= − 0·0303

NOVEMBER 29 AND 30.

Juno compared with ν.

	First system	Second system
5·320 Δα + 1·053 Δδ − 0·051 Δπ . . .	= − 3·742	= − 6·862
1·053 Δα + 3·507 Δδ + 0·059 Δπ . . .	= − 6·794	= − 6·441
− 0·051 Δα + 0·059 Δδ + 0·0045 Δπ . . .	= − 0·0908	= − 0·0340

The resulting values are—

	November 12 *and* 13.		*November* 25 *and* 26.		*November* 29 *and* 30.	
	First system	Second system	First system	Second system	First system	Second system
$\Delta\alpha$	− 0·666	− 1·959	0·913	− 0·072	− 0·265	− 0·942
$\Delta\delta$	− 1·345	− 1·402	− 1·350	− 1·144	− 1·883	− 1·599
$\Delta\pi$	− 0·81	− 0·73	− 1·01	− 1·47	1·51	2·69

To deduce the definitive value of $\Delta\pi$ from all these results we form equations, in each of which the coefficient of $\Delta\pi$ is the sum of the squares of the coefficients in the equations which determine $\Delta\pi$, and the attached weights are the mean number of groups of observations on which each equation depends.

[On November 29 and 30 both factors are negative, and the coefficient is the difference of the squares.]

The following are the equations so deduced:—

		First system	Second system	Weight
From comparisons with single stars . .	November 12 and 13 . .	0·0105 $\Delta\pi$ = − 0·0085	= − 0·0077	4
	„ 25 and 26 . .	0·0073 $\Delta\pi$ = − 0·0074	= − 0·0107	3
	„ 29 and 30 . .	0·0036 $\Delta\pi$ = + 0·0054	= + 0·0097	2
From comparisons with two stars . . .	November 15 . . .	0·0102 $\Delta\pi$ = − 0·0423	= − 0·0417	2
	„ 18 and 19 . .	0·0093 $\Delta\pi$ = − 0·0054	= − 0·0051	2
	„ 23 and 24 . .	0·0137 $\Delta\pi$ = + 0·0078	= + 0·0017	2

And the definitive values are—

I	1st System	2nd System
$\Delta\pi$ =	− 0·91 ± 0·460	−0·97 ± 0·472.

The assumed value of the mean solar parallax was 8″·85; hence the values resulting from our discussion—

1st System	2nd System
8″·77 ± 0″·041	8″·76 ± 0″·042.

The values of these probable errors depend on too few observations to be trustworthy; nor do we ourselves attach high importance to the value of the parallax deduced.[1] But that to which we do attach great importance is the very remarkable accuracy of the method when this value of the parallax is substituted in the equations—as in the following table of the residuals which represent the errors of the observations of distance:—

	First system	Second system
November 12, evening, θ	+ 0″·088	+ 0″·103
„ morning, θ	+ 0·129	+ 0·134
„ 13, evening, θ	− 0·038	− 0·034

---

[1] There is a discordant value on November 15, which in a larger series would probably have been counterbalanced by another, in which all the sources of error had combined in the opposite way; and thus, if we were asked what we believe to be the most probable value resulting from the determination, we should reject this result; the values then become—

First system	Second system
8″·82	8″·81.

At the same time we are aware that the rejection of any observation is quite unsound.

	First system	Second system
November 13, morning, θ	$-0''.084$	$-0''.094$
„ 15, evening, ζ	− 0·074	− 0·075
„ „ λ	+ 0·114	+ 0·113
„ morning, ζ	+ 0·206	+ 0·199
„ „ λ	− 0·213	− 0·206
„ 18 „ θ	− 0·003	− 0·001
„ „ μ	+ 0·012	+ 0·023
„ 19, evening, θ	+ 0·021	+ 0·024
„ „ μ	− 0·016	− 0·020
„ 23 „ ι	+ 0·075	+ 0·053
„ „ χ	− 0·080	− 0·060
„ 24, morning, ι	− 0·102	− 0·069
„ „ χ	+ 0·101	+ 0·073
„ 25, evening, μ	− 0·081	− 0·134
„ morning, μ	− 0·004	− 0·042
„ 26, evening, μ	− 0·153	− 0·176
„ morning, μ	− 0·051	− 0·073
„ 29 „ ν	− 0·019	− 0·180
„ 30, evening, ν	− 0·194	− 0·259

The resulting probable error for a complete observation is from this table on the 1st system $\pm 0''.073$, and on the 2nd system $\pm 0''.082$, confirming beyond all doubt the conclusion at which we arrived in the paper referred to in our introduction, viz. that it is possible, by means of the heliometer, to determine the place of a minor planet relative to two stars (or if within a distance of 1000″, to one star), with a probable error of less than a tenth of a second of arc.

Considering that it was impossible to commence observations until a week after opposition, and that in consequence hardly one-third of the anticipated observations were secured, and these in circumstances the least favourable for parallax factor, we do not attach very much importance to the value of the parallax deduced. But we have at least now sound data upon which to found calculation as to the value of the opposition of any minor planet for the future determination of the solar parallax.

It is also quite possible that some small systematic error may attach to the result, due to imperfection in the tabular corrections. We leave this a matter for after discussion, the equations being left in a form which renders it very easy to apply any corrections different from those contained in our table (pp. 148–177), which may result from improved tables of Juno.

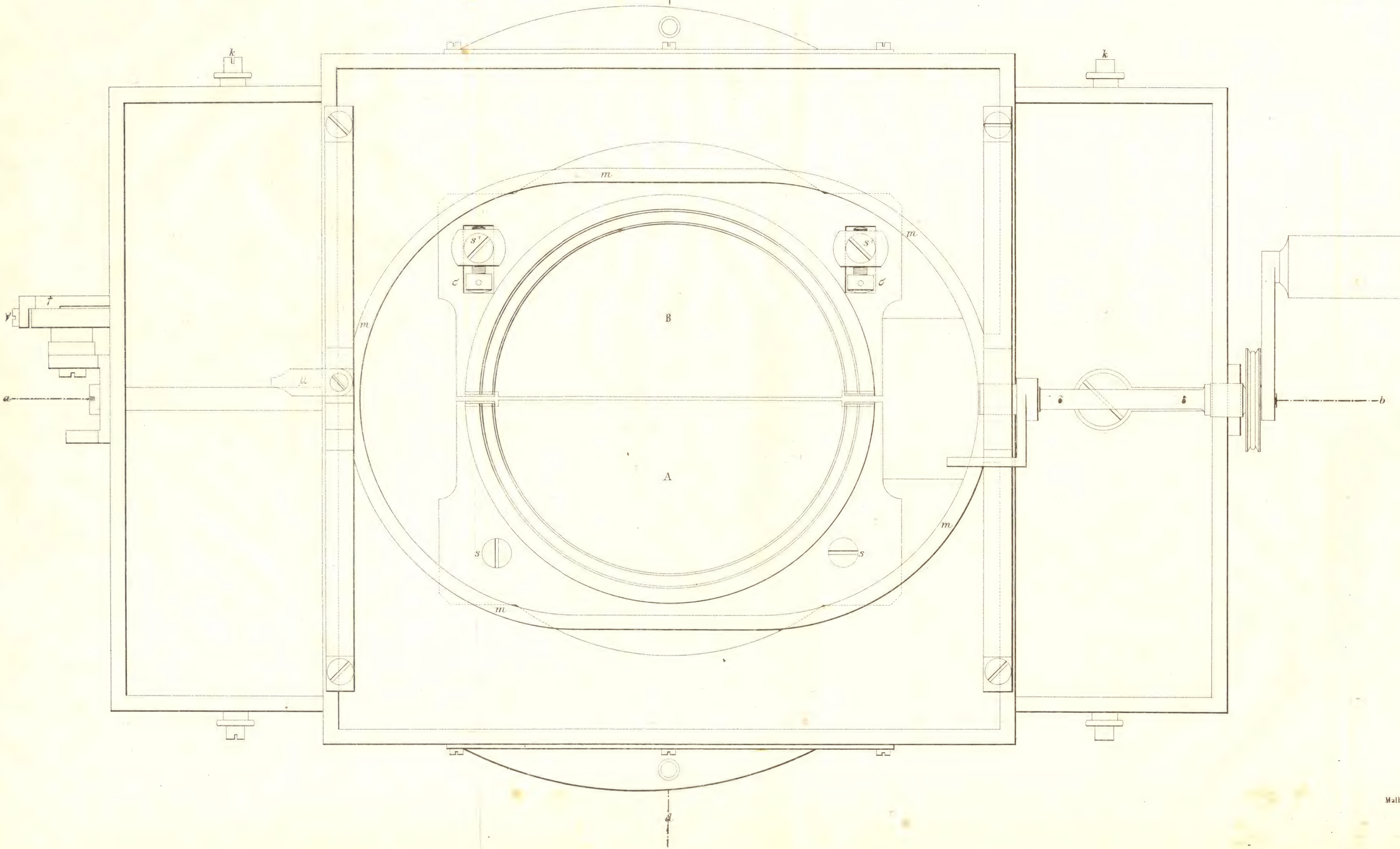
The errors of the tabular geocentric places resulting from the heliometer observations and Dr. Copeland's star-places are as follow :—

	d.	$\Delta\alpha$	$\Delta\delta$
G.M.T. 1874.	November 12·858	$+124''.26$	$+15''.19$
„	15·331	124·86	15·44
„	18·821	122·94	14·41
„	23·807	121·10	13·07
„	25·746	120·24	13·07
„	29·722	+ 116·59	+ 11·78

in which the right ascensions depend on the Greenwich Catalogue for 1864, and the declinations on the Berlin 'Mittlere Oerter von 539 Sternen.'

Spottiswoode & Co., Printers, New-street Square, London.

PLATE . I .



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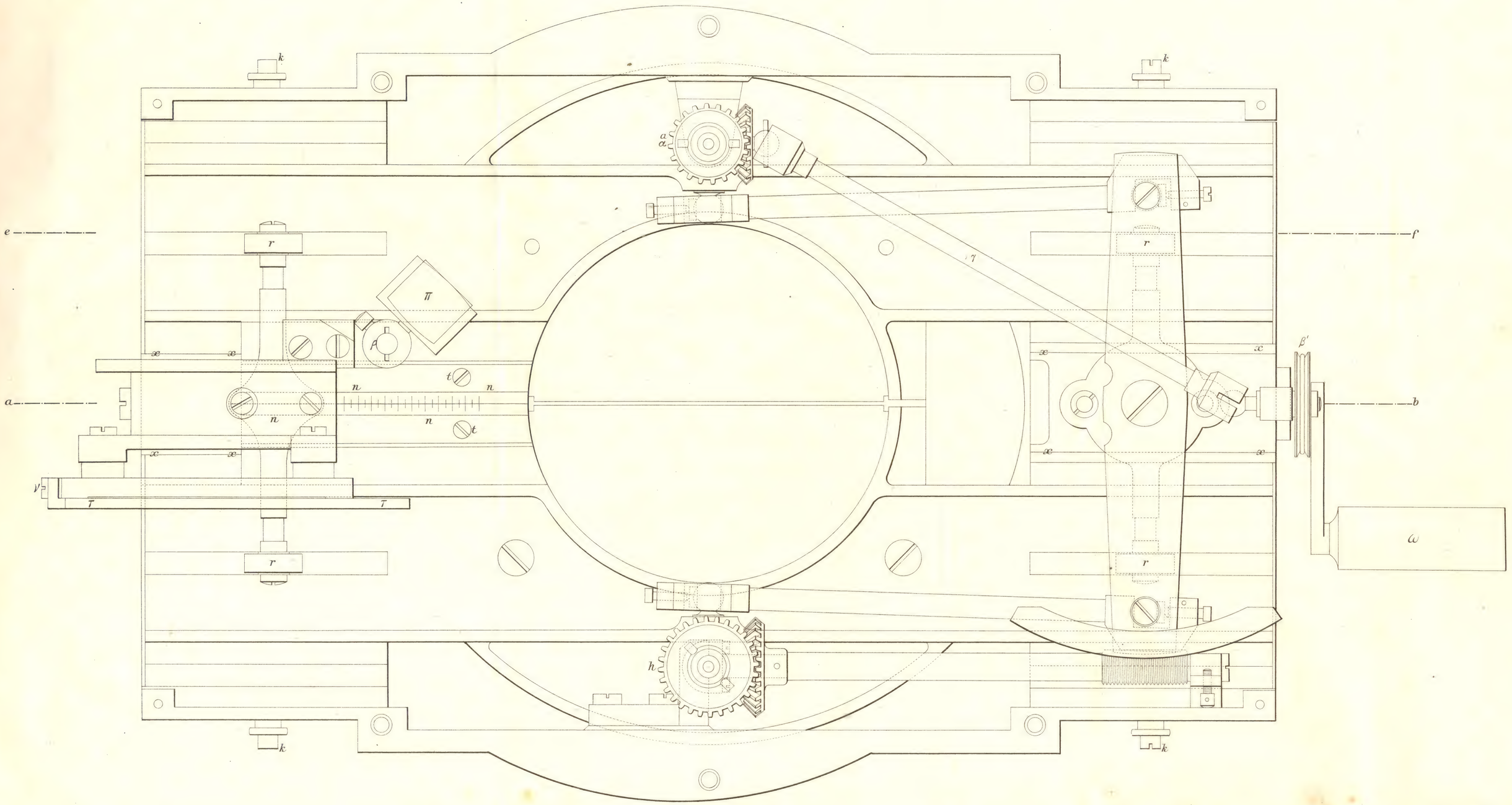

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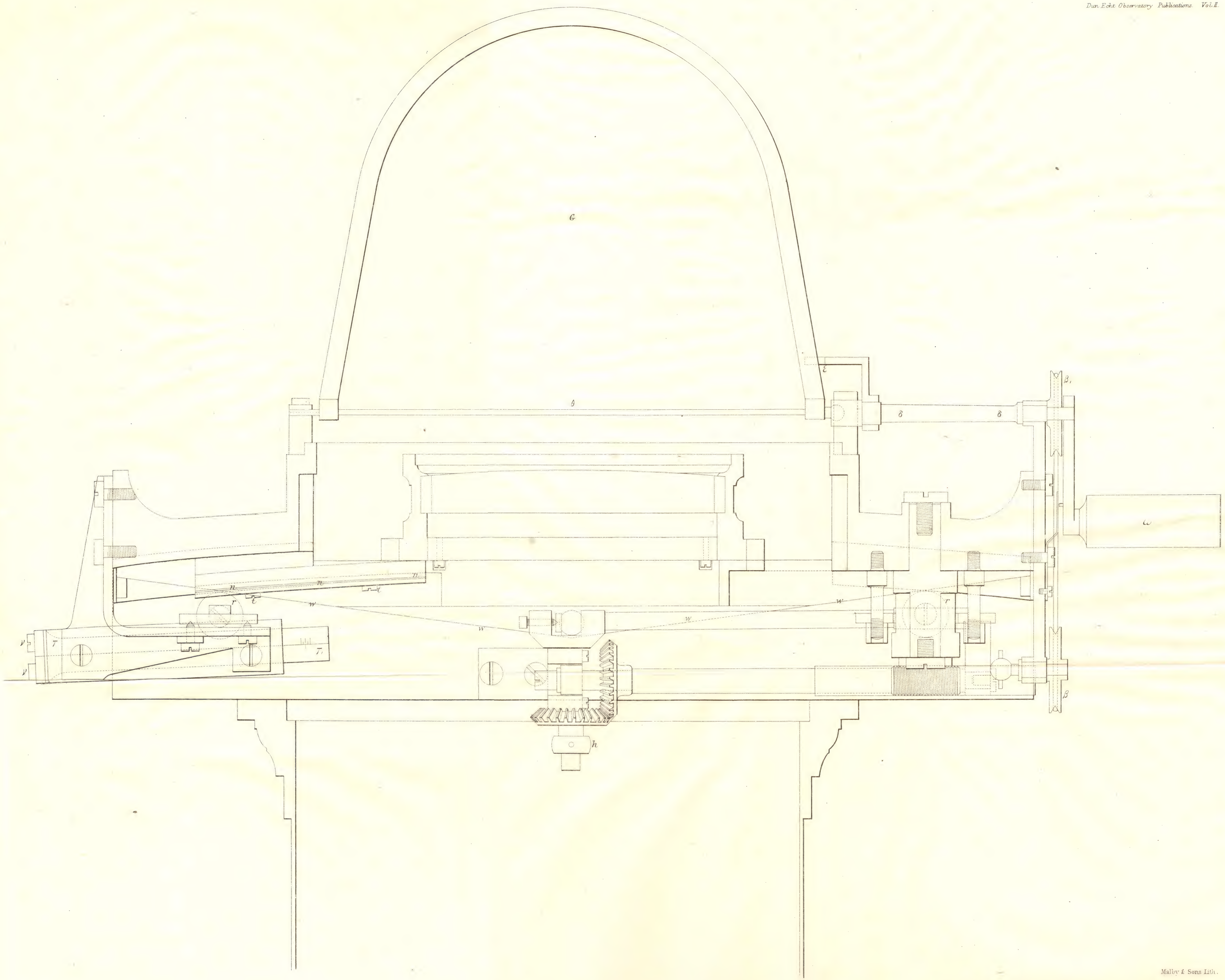

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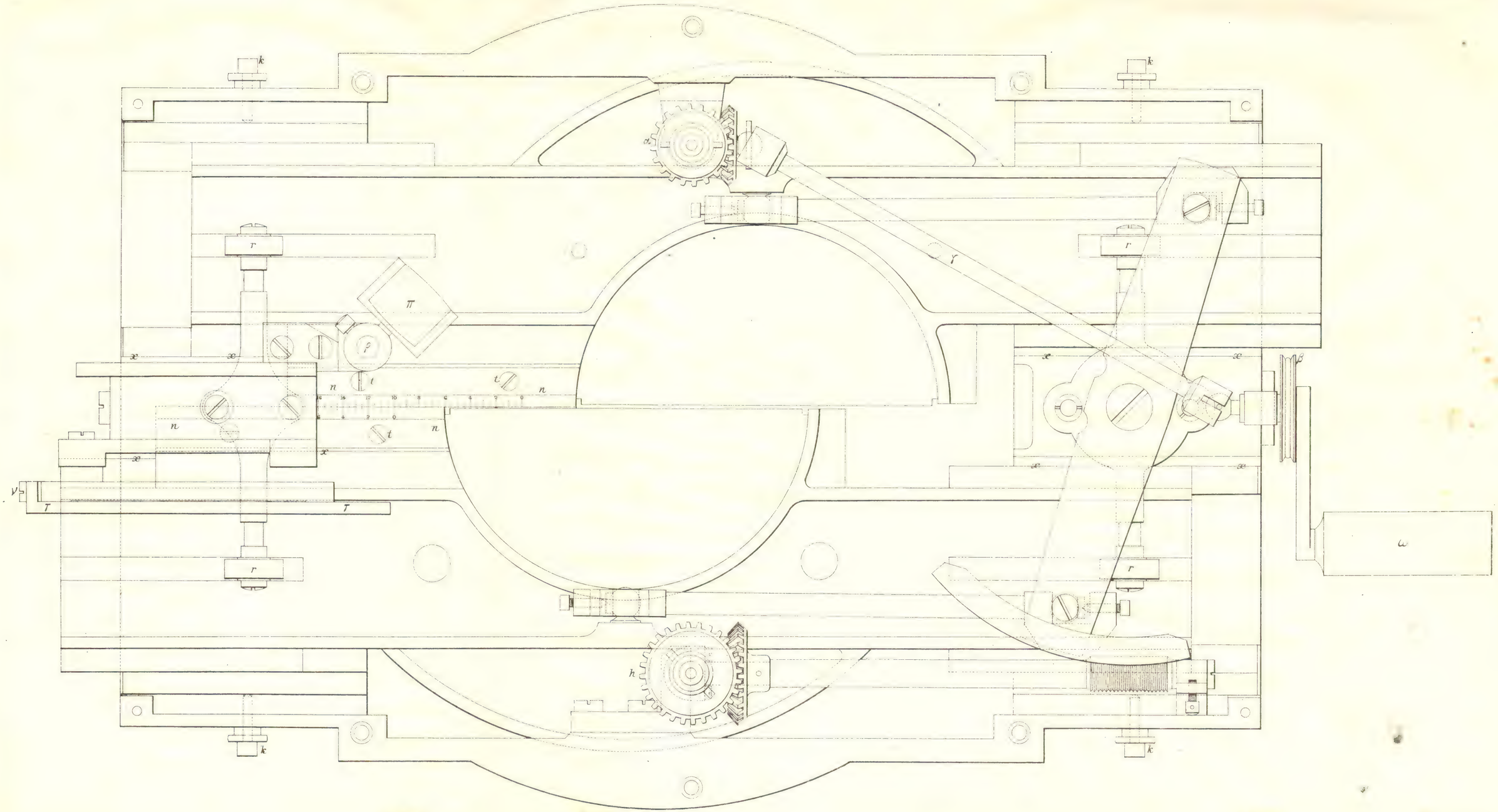

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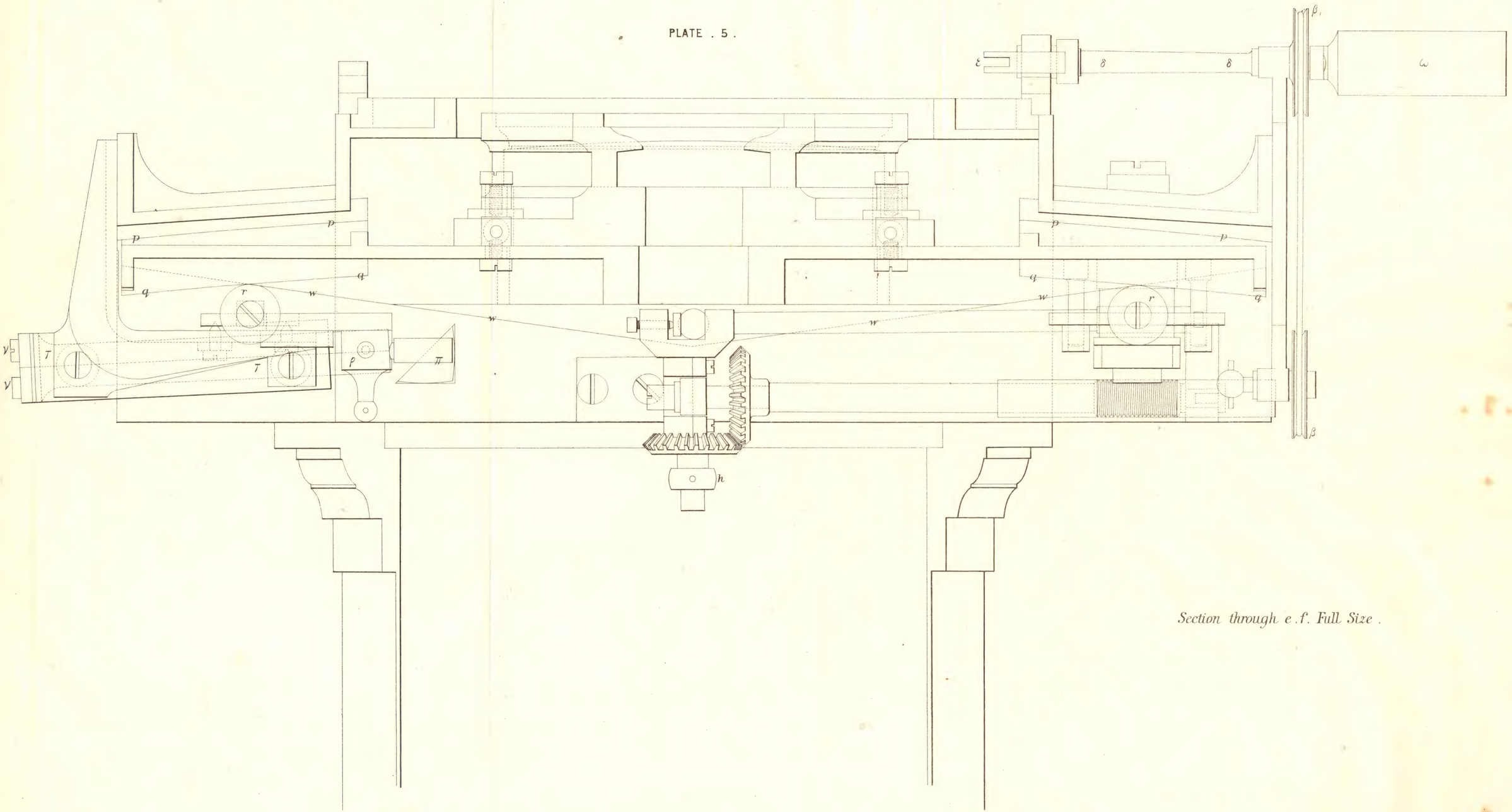
PLATE . 5 .



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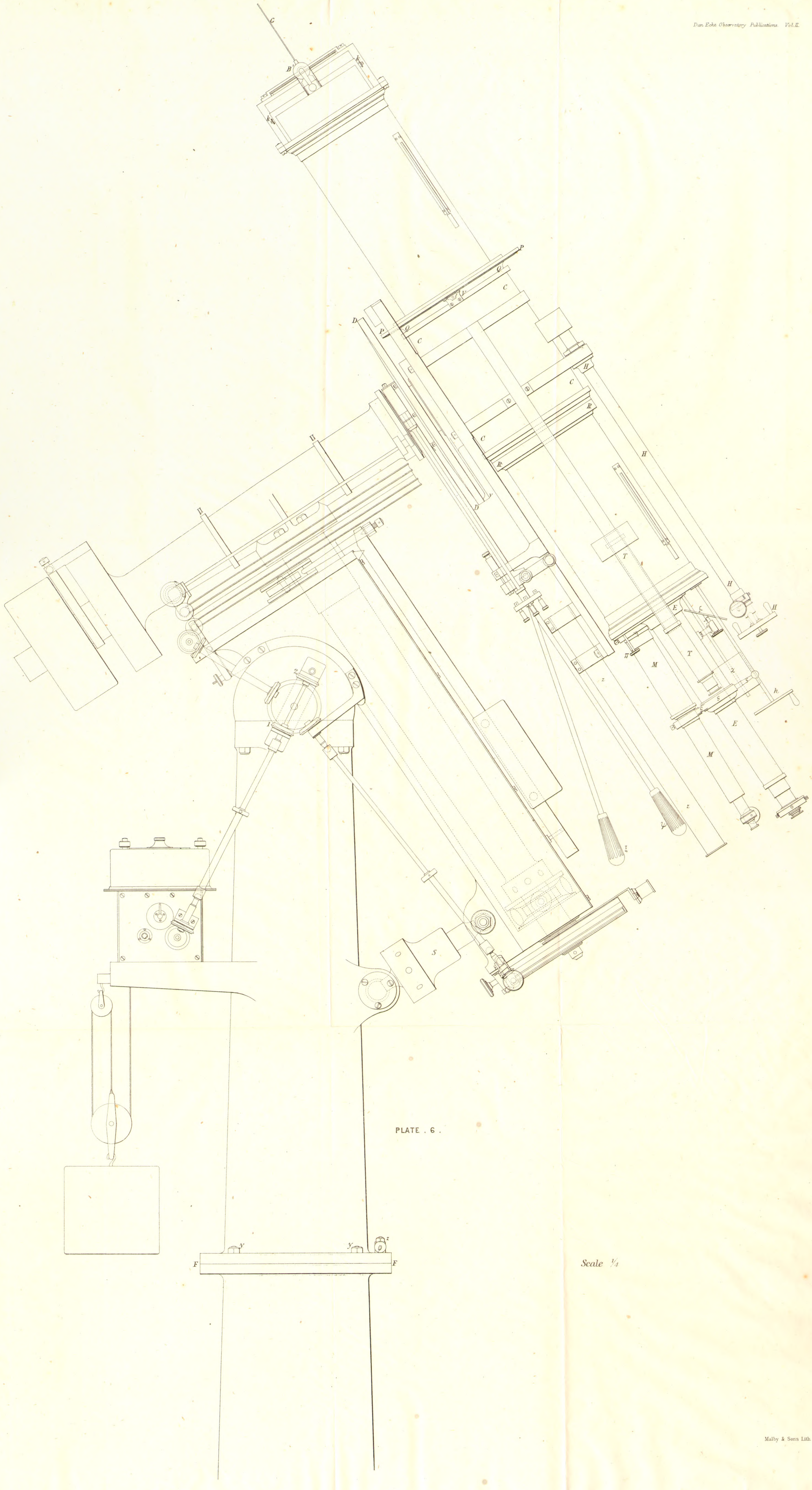

PLATE . 6 .

Scale 1/4

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